NASA SP-7011 (407)
November 1995

AEROSPACE MEDICINE AND BIOLOGY

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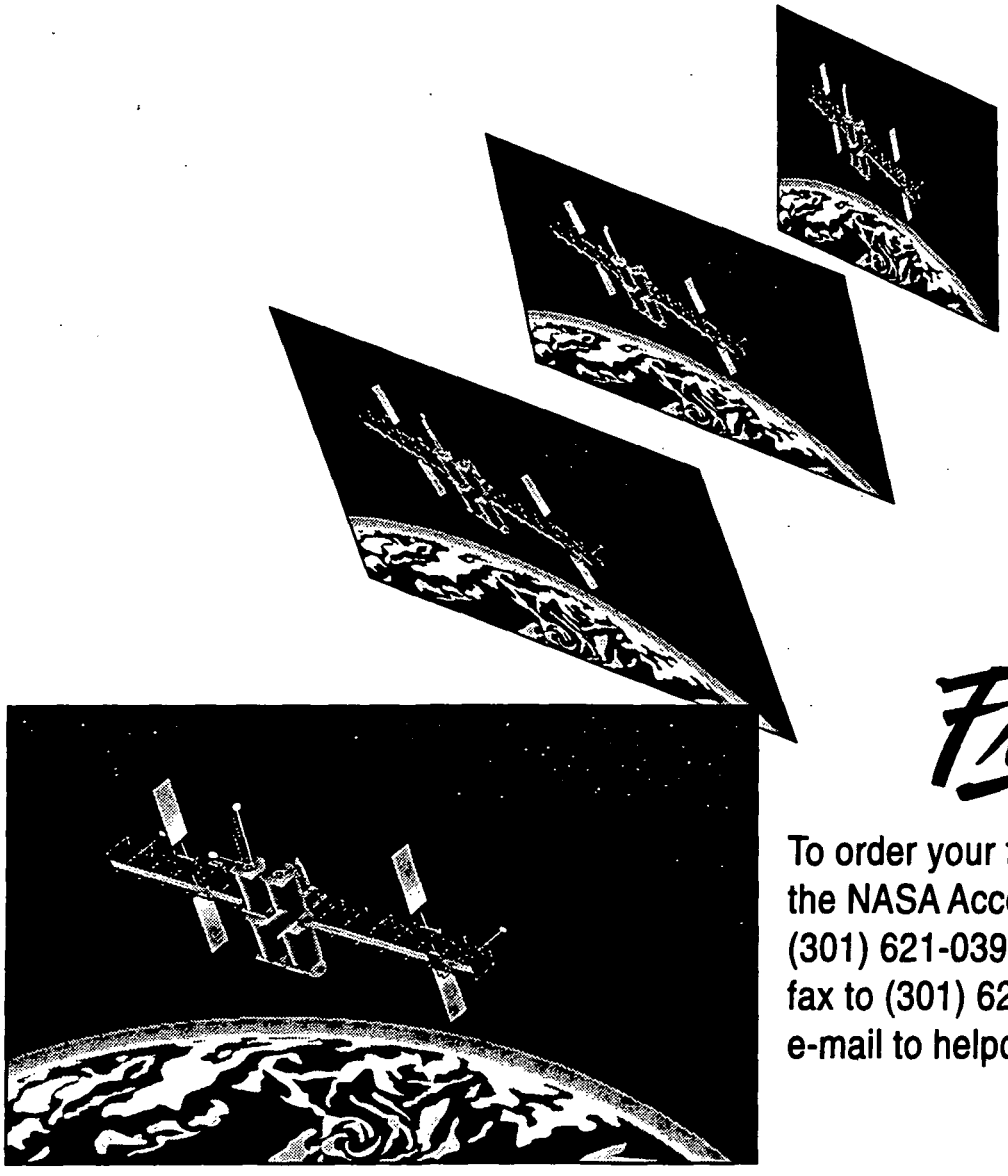

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INTRODUCTION

This issue of *Aerospace Medicine and Biology* (NASA SP-7011) lists 289 reports, articles, and other documents recently announced in the NASA STI Database. The first issue of *Aerospace Medicine and Biology* was published in July 1964.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N95-30358 — N95-32372
Open Literature (A-60000 Series)	A95-92371 — A95-95938

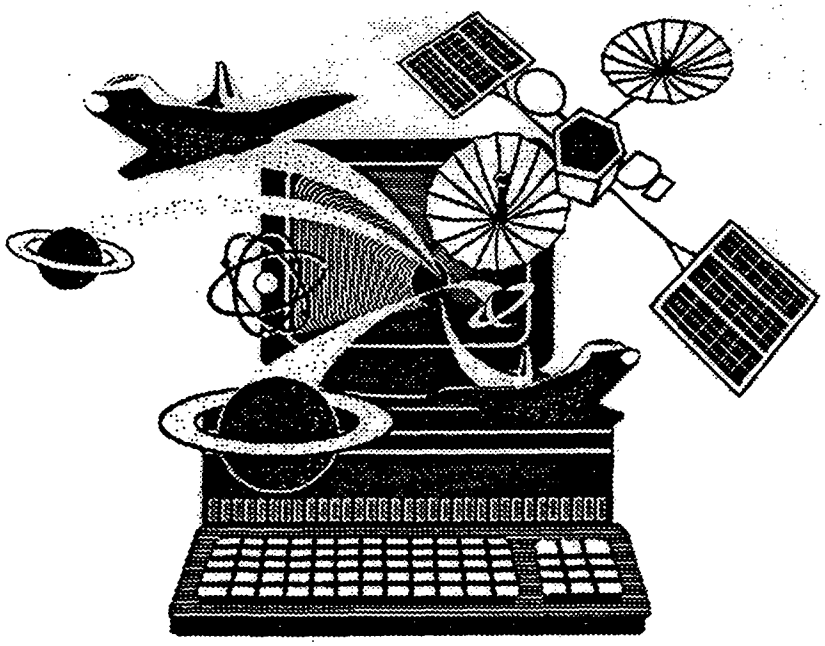
In its subject coverage, *Aerospace Medicine and Biology* concentrates on the biological, physiological, psychological, and environmental effects to which humans are subjected during and following simulated or actual flight in the Earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Applied research receives the most emphasis, but references to fundamental studies and theoretical principles related to experimental development also qualify for inclusion.

Each entry in the publication consists of a standard bibliographic citation accompanied, in most cases, by an abstract. The listing of the entries is arranged by *STAR* categories 51 through 55, the Life Sciences division. The citations include the original accession numbers from the NASA STI Database.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1995 will be published in early 1996.

The NASA CASI price code table, addresses of organizations, and document availability information are located at the back of this issue.



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10/95

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TYPICAL REPORT CITATION AND ABSTRACT

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ACCESSION NUMBER → N95-10863*# National Aeronautics and Space Administration. ← CORPORATE SOURCE
Ames Research Center, Moffett Field, CA.
TITLE → BIOTELEMETRY IMPLANT VOLUME AND WEIGHT IN RATS: A PILOT STUDY REPORT
AUTHOR → CHRIS J. SOMPS May 1994 19 p ← PUBLICATION DATE
CONTRACT NUMBER → (Contract RTOP 545-20-01)
REPORT NUMBERS → (NASA-TM-108812; A-94059; NAS 1.15:108812) Avail: CASI HC ← AVAILABILITY AND PRICE CODE
A03/MF A01

This paper reports the results of a pilot study in which a 240-gram rat was implanted for 41 days with biotelemetry devices weighing a total of 36 gm (18 cc). The implanted animal showed no differences in weight gain, food and water consumption, and postnecropsy organ weights when compared to both an unoperated control animal and an animal that underwent surgery but did not receive an implant. The implanted animal also had temperature and activity rhythms similar to those reported using much smaller implants. Thus, this pilot study showed that a 240-gm rat could be implanted with biotelemetry devices weighing nearly 15 percent of body weight without significant changes in health or behavior. A larger study involving more animals and similar implant sizes is recommended. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → A95-63745* National Aeronautics and Space Administration. John F. ← CORPORATE SOURCE
Kennedy Space Center, Cocoa Beach, FL.
TITLE → THE ORIGIN AND EARLY EVOLUTION OF ISSOL
AUTHOR → RICHARD S. YOUNG NASA. Kennedy Space Center, Cocoa Beach, ← AUTHORS' AFFILIATION
FL, US ISSOL Meeting, 7th, Barcelona, Spain, July 4-9, 1993.
PRIMARY DOCUMENT → A95-63744 Origins of Life and Evolution of the Biosphere (ISSN 0169- ← JOURNAL TITLE
6149) vol. 24, no. 2-4. June 1994 p. 83 ← PUBLICATION DATE
Copyright

This is a discussion of the beginnings of the International Society for the Study of the Origin of Life (ISSOL)—how it came to be and the people responsible for it. It will include the early meetings on the subject of the Origin of Life which led to the formation of the Society. It will discuss the genesis of the interest of NASA in such a program and how the Exobiology Program got started, leading up to the Viking Program and the early exploration of Mars. Photographs of early meetings and the scientists involved will be included. Author (Hemer)

AEROSPACE MEDICINE AND BIOLOGY

A Continuing Bibliography (Suppl. 407)

November 1995

ABSTRACTS

51
LIFE SCIENCES (GENERAL)

A95-92524
TISSUE OPTICS, LIGHT DISTRIBUTION, AND SPECTROSCOPY
VALERY V. TUCHIN Saratov State Univ., Saratov, Russia, SERGEI R. UTZ, and ILYA V. YAROSLAVSKY Optical Engineering (ISSN 0091-3286) vol. 33, no. 10 10 1994 p. 3178-3188 refs
(BTN-95-EIX95292661188) Copyright

A model of multilayered tissue is considered. The Monte Carlo simulation technique is used to study laser beam transport through tissues with varying optical properties for each layer (absorption, scattering, scattering anisotropy factor, and refractive index). Calculations are performed for some models of the human skin and adjacent tissues for visible and UV wavelength ranges. New technology for human epidermis optical parameters determination is presented. This technology includes epidermis upper layers glue stripping; in vitro measurements of total transmission, diffuse reflection, and angular scattering of stripping samples; and using an inverse calculation technique based on four-flux approximation of radiation transport theory. The technology was successfully used for depth dependence monitoring of epidermis optical parameters. An inverse Monte Carlo technique for determining the optical properties of tissues based on spectrophotometric measurements is developed. This technique takes into accounts the 2-D geometry of the experiment, finite sizes of incident beam and integrating sphere ports, boundary conditions, and sideways losses of light. Author (EI)

A95-92688
DNA SOLUTION OF HARD COMPUTATIONAL PROBLEMS
RICHARD J. LIPTON Princeton Univ, Princeton, NJ, United States Science (ISSN 0036-8075) vol. 268, no. 5210 April 28 1995 p. 542-545 refs
(BTN-95-EIX95292725315) Copyright

DNA experiments are proposed to solve the famous 'SAT' problem of computer science. This is a special case of a more general method that can solve NP-complete problems. The advantage of these results is the huge parallelism inherent in DNA-based computing. It has the potential to yield vast speedups over conventional electronic-based computers for such search problems. Author (EI)

A95-93759 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LIFE SCIENCES AND SPACE RESEARCH 25 (3): NATURAL AND ARTIFICAL ECOSYSTEMS; MEETING F4 OF THE COSPAR PLENARY MEETING, 29TH, WASHINGTON, DC, AUG. 28-SEP. 5, 1992
R. D. MACELROY, editor NASA-Ames Research Center, Moffett Field, California, US, C. A. MITCHELL, editor NASA Specialized Center of Research, West Lafayette, Indiana, US, M. ANDRE, editor Centre de Cadarache, France, C. C. BLACKWELL, editor NASA-Ames Research Center, Moffett Field, California, US, T. W. TIBBITTS, editor Department of Horticulture, Madison, Wisconsin, US, A. BANIN, editor The Hebrew University, Israel, and J. S. LEVINE, editor NASA Langley Research Center, Hampton, Virginia, US Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 466 p.
(ISBN 0-08-042488-0; HTN-95-B0509) Copyright

Bioregenerative life support systems will be an essential part of long duration manned space flight. Studies have been made of various components of these closed ecological systems. These studies have included those spaceborne experiments on Spacelab and Mir, as well as ground-based simulations. The effects of reduced gravity include alterations in food crop and other plant growth and vigor. Systems have also been designed and tested to provide a balanced regenerative system that recycles airborne and other wastes while providing nutrients and other input for future cycles. Hydroponic cultivation must include control of pathogens. All closed systems require sensing and automatic control. For individual titles, see A95-93760 through A95-93818. Herner

A95-93760 National Aeronautics and Space Administration, Washington, DC.
SEEDLING GROWTH AND DEVELOPMENT ON SPACE SHUTTLE
J. COWLES Virginia Polytechnic Institute and State University, Blacksburg, Virginia, U, R. LEMAY University of Houston, Houston, Texas, US, and G. JAHNS University of Houston, Houston, Texas, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)3-(11)12
Copyright

Young pine seedlings, and mung bean and oat seeds were flown on shuttle flights, STS-3 and STS-51F, in March, 1982 and July/August, 1985, respectively. The plant growth units built to support the two experiments functioned mechanically as anticipated and provided the necessary support data. Pine seedlings exposed to the microgravity environment of the space shuttle for 8 days continued to grow at a rate similar to ground controls. Pine stems in flight seedlings, however, averaged 10 to 12% less lignin than controls. Flight mung beans grew slower than control beans and their stems contained about 25% less lignin than control seedlings. Reduced mung bean growth in microgravity was partly due to slower germination rate. Lignin also was reduced in flight oats as compared to controls. Oats and mung beans exhibited upward growing roots which were not observed in control seedlings. Chlorophyll A/B ratios were lower in flight tissues than controls. The sealed PGCs exhibited large variations in atmospheric gas composition but the changes were similar between flight and ground controls. Ethylene was present in low concentrations in all chambers.
Author (revised by Herner)

A95-93761
'FROM SEED-TO-SEED' EXPERIMENT WITH WHEAT PLANTS UNDER SPACE-FLIGHT CONDITIONS
A. MASHINSKY Institute of Biomedical Problems, Moscow, Russia, I. IVANOVA Institute of Biomedical Problems, Moscow, Russia, T. DERENDYAEVA Institute of Biomedical Problems, Moscow, Russia, G. NECHITAILO Institute of Biomedical Problems, Moscow,

Russia, and F. SALISBURY Utah State University, Logan, Utah, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)13-(11)19

An important goal with plant experiments in microgravity is to achieve a complete life cycle, the 'seed-to-seed experiment.' Some Soviet attempts to reach this goal are described, notably an experiment with the tiny mustard, Arabidopsis thaliana, in the Phyton 3 device on Salyut 7. Normal seeds were produced although yields were reduced and development was delayed. Several other experiments have shown abnormalities in plants grown in space. In recent work, plants of wheat (Triticum aestivum) were studied on the ground and then in a preliminary experiment in space. Biometric indices of vegetable space plants were 2 to 2.5 times lower than those of controls, levels of chlorophyll a and b were reduced (no change in the ratio of the two pigments), carotenoids were reduced, there was a serious imbalance in major minerals, and membrane lipids were reduced (no obvious change in lipid patterns). Following the preliminary studies, an attempt was made with the Svetoblock-M growth unit to grow a super-dwarf wheat cultivar through a life cycle. The experiment lasted 167 d on Mir. Growth halted from about day 40 to day 100, when new shoots appeared. Three heads had appeared in the boot (suurounded by leaves) when plants were returned to earth. One head was sterile, but 28 seeds matured on earth, and most of these have since produced normal plants and seeds. In principle, a seed-to-seed experiment with wheat should be successful in microgravity.

Author (revised by Herner)

A95-93763

THE ASTROCULTURE FLIGHT EXPERIMENT SERIES, VALIDATING TECHNOLOGIES FOR GROWING PLANTS IN SPACE

R. C. MORROW University of Wisconsin, Madison, Wisconsin, US, R. J. BULA University of Wisconsin, Madison, Wisconsin, US, T. W. TIBBITTS University of Wisconsin, Madison, Wisconsin, US, and W. R. DINAUER University of Wisconsin, Madison, Wisconsin, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)29-(11)37

A flight experiment, ASTROCULTURE - 1 (ASC-1), to evaluate the operational characteristics and hardware performance of a porous tube nutrient delivery system (PTNDS) was flown on STS-50 as part of the U.S. Microgravity Laboratory-1 mission, 25 June to 9 July, 1992. This experiment is the first in a series of planned ASTROCULTURE flights to validate the performance of subsystems required to grow plants in microgravity environments. Results indicated that the PTNDS was capable of supplying water and nutrients to plants in microgravity and that its performance was similar in microgravity to that in 1 g on Earth. The data demonstrated that water transfer rates rates through a rooting matrix are a function of pore size of the tubes, the degree of negative pressure on the 'supply' fluid, and the pressure differential between the 'supply' and 'recovery' fluid loops. A slightly greater transfer rate was seen in microgravity than in 1 g, but differences were likely related to the presence of hydrostatic pressure effects at 1 g. Thus, this system can be used to support plant growth in microgravity or in partial gravity as on a lunar or Mars base. Additional subsystems to be evaluated in the ASTROCULTURE flight series of experiments inlude lighting, humidity control and condensate recovery, temperature control, nutrient composition control, CO2 and O2 control, and gaseous contaminant control.

Author (revised by Herner)

A95-93764

PECULIARITIES OF MOISTURE TRANSFER IN CAPILLARY-POROUS SOIL SUBSTITUTES DURING SPACE FLIGHT

I. PODOLSKY Institute of Biomedical Problems, Moscow, Russia and A. MASHINSKY Institute of Biomedical Problems, Moscow, Russia Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)39-(11)46

Aboard the orbital stations, Saylut-7 and Mir, investigations on the peculiarities of moisture transfer in capillary-porous bodies (CPB; that is, the soil substitutes) in microgravity were conducted by the authors with a specifically design device and an original method. Water distribution in CPB-perlite (fractions 1.5 ... 2.5 mm) was studied, and theoretical dependances for linear capillary impregnation of CPB were determined. Author (revised by Herner)

A95-93765 National Aeronautics and Space Administration, Washington, DC.

POROUS TUBE PLANT NUTRIENT DELIVERY SYSTEM DEVELOPMENT: A DEVICE FOR NUTRIENT DELIVERY IN MICROGRAVITY

T. W. DRESCHEL The Bionetics Corporation, Florida, US, C. S. BROWN The Bionetics Corporation, Florida, US, W. C. PIASTUCH The Bionetics Corporation, Florida, US, C. R. HINKLE The Bionetics Corporation, Florida, US, and W. M. KNOTT NASA, Florida, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)47-(11)51

The Porous Tube Plant Nutrient Delivery Systems or PTPNDS (U.S. Patent #4,926,585) has been under development for the past six years with the goal of providing a means for culturing plants in microgravity, specifically providing water and nutrients to the roots. Direct applications of the PTPNDS include plant space biology investigations on the Space Shuttle and plant research for life support in the Space Station Freedom. In the past, we investigated various configurations, the suitability of different porous materials, and the effects of pressure and pore size on plant growth. Current work is focused on characterizing the physical operation of the system, examining the effects of solution aeration, and developing prototype configurations for the Plant Growth Unit (PGU), the flight system for the Shuttle mid-deck. Future developments will involve testing on KC-135 parabolic flights, the design of flight hardware and testing aboard the Space Shuttle. Author (revised by Herner)

A95-93766* National Aeronautics and Space Administration, Washington, DC.

PLANT-MODULE FOR AUTONOMOUS SPACE-SUPPORT (P-MASS).

M. W. LUTTGES University of Colorado, Boulder, Colorado, US, L. STODIECK University of Colorado, Boulder, Colorado, US, and A. HOEHN University of Colorado, Boulder, Colorado, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)53-(11)60 (Contract(s)/Grant(s): NAGW-1197)

A wide variety of technical and science questions arise when attempting to envision the long-term support of plants, algae and bacteria in space. Currently, spaceflight data remain elusive since there are no U.S. carriers for investigating either the germane technical or scientific issues. The first flight of the Commercial Experiment Transporter (COMET) will provide a nominal 30 day orbital opportunity to evlauate such issues. The P-Mass is a small

payload that is designed to meet the mass (40 lbs), Volume (1.5cu. ft.), and power (120 W0 constraints of one of several COMET payloads while enabling flight evaluations of plants, algae and bacteria. Various biological sub-systems have been similarly evaluated. Through a variety of sensors coupled with color video, the P-Mass performance and the supported biological systems will be compared for terrestrial controls versus spaceflight materials. This small, low cost payload should return valuable regarding the requirements for hardware and biological systems needed to move toward biogenerative life support systems in space. In addition, it should be possible to accurately identify major unresolved difficulties that may arise in the long-term, this generic spaceflight capability should enable a variety of plant research programs focused on the use of microgravity to modulate and exploit plant products for commercial applications ranging from new agricultural products to pharmacological feedstocks and new controlled agricultural strategies.

Author (revised by Hemer)

A95-93771
C.E.B.A.S. MINI MODULE: TEST RESULTS OF AN ARTIFICIAL (MAN-MADE) AQUATIC ECOSYSTEM

V. BLUM Ruhr-University Bochum, Germany, K. KREUZBERG Germand Aerospace Establishment, Germany, and E. STRETZKE Ruhr-University Bochum, Germany Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)89-(11)98

The original Closed Equilibrated Biological Aquatic System (C.E.B.A.S.) is a long-term multi-generation research facility for experiments with aquatic animals and plants in a space station the development of which is surrounded by a large international scientific program. In addition, a miniaturized laboratory prototype, the C.E.B.A.S. MINI MODULE, with a total volume of about 10 - 12 liters for a Spacelab middeck locker was develped and a first version was tested successfully for two weeks with a population of fishes (Xiphophorus helleri) in the animal tank and a Ceratophyllum spec. in the illuminated higher plant growth chamber. The water recycling system consisted of a bacteria filter and the silastic tubing gas exchanger was separated by valves for the utlization in emergency cases only. Data were collected with the acquisition module of the original C.E.B.A.S. process control system. In addition, an optimized version was tested for 7 weeks with fishes and plants and thereafter with fish and with plants only for 2 and 1 weeks, resp.. The paper presents the relevant water parameters (e.g., pH, pressure, temperature, oxygen saturation, flow rate, ion concentrations) during the test period as well as morphological and physiological data of the enclosed animals and plants. On the basis of the given results the possible role of the C.E.B.A.S. systems as a scientific tool in artificial ecosystem research and for the development of a combined animal-plant intensive aquaculture system and its utilization in bioregenerative life support is discussed.

Author (revised by Hemer)

A95-93780
PROXIMATE NUTRITIONAL COMPOSITION OF CELSS CROPS GROWN AT DIFFERENT CO2 PARTIAL PRESSURES

R. M. WHEELER Kennedy Space Center, Florida, US, C. L. MACKOWIAK Kennedy Space Center, Florida, US, J. C. SAGER Kennedy Space Center, Florida, US, W. M. KNOTT Kennedy Space Center, Florida, US, and W. L. BERRY Kennedy Space Center, Florida, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)171-(11)176

Two Controlled Ecological Life Support System (CELSS) candidate crops, soybean (Glycine max) and potato (Solanum tuberosum), were grown hydroponically in controlled environments maintained at carbon dioxide (CO2) partial pressures ranging from 0.05 to 1.00 kPa (500 to 10,000 ppm at 101 kPa atmospheric pressure). Plants were harvested at maturity (90 days for soybean and 105 days for potato) and all tissues analyzed for proximate nutritional composition (i.e. protein, fat, carbohydrate, crude fiber, and ash content). Soybean seed ash and crude fiber were higher and carbohydrate was lower than values reported for field-grown seed. Potato tubers showed little difference from field-grown tubers. Crude fiber of soybean stems and leaves increased with increased CO2, as did soybean leaf protein (total nitrogen). Potato leaf and stem (combined) protein levels also increased with increased CO2, while leaf and stem carbohydrates decreased. Values for leaf and stem protein and ash were higher than values generally reported for field-grown plants for both species. Results suggest that CO2 partial pressure should have little influence on proximate composition of potato tubers or soybean seed, but that high ash and protein levels might be expected from leaves and stems of crops grown in controlled environments of a CELSS. Author (revised by Hemer)

A95-93782
SYSTEMS APPROACH TO INSTRUMENTING AND CONTROLLING PLANT GROWTH SYSTEMS

G. A. GIACOMELLI Rutgers University, New Brunswick, New Jersey, US, K. C. TING Rutgers University, New Brunswick, New Jersey, US, and P. P. LING Rutgers University, New Brunswick, New Jersey, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)191-(11)197

Acquisition and analysis of sensory information are foremost for the control and continued operation of any complex system. The sensors and their attributes must be selected by understanding the biological and physical parameters which, first, can describe, and second, when linked to control systems, can modulate, the plant growth system. These parameters are not all understood, or known, and practical sensors may not even exist for their measurement. A systematic analysis of the general plant system would: focus without prejudice on all the descriptive parameters, as well as, their interrelationships within the biophysical system; highlight the significance of each parameter; expose the areas of weakness and strength of current knowledge; expand the knowledge base; provide the platform for the development of operational models for real-time monitoring and control requirements; and support the longer term tactical and strategic planning needs. Components of such a procedure of systematic analysis which is in development for intensive plant production sytems within controlled environments will be discussed.

Author (revised by Hemer)

A95-93783* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
ANALYSIS OF REMOTE REFLECTION SPECTROSCOPY TO MONITOR PLANT HEALTH

R. WOODHOUSE Agave Analytics, Los Angeles, California, US, M. HEEB Agave Analytics, Los Angeles, California, US, W. BERRY Agave Analytics, Los Angeles, California, US, T. HOSHIZAKI Agave Analytics, Los Angeles, California, US, and M. WOOD Agave Analytics, Los Angeles, California, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)199-(11)202
(Contract(s)/Grant(s): NAS10-11668)

Remote non-contact reflection spectroscopy is examined as a method for detecting stress in Controlled Ecological Life Support System (CELSS) type crops. Lettuce (Latuca Sativa L. cv. Waldmans Green) and wheat (Triticum Aestivum L. cv. Yecora Rojo) were grown hydroponically. Copper and zinc treatments provided toxic

conditions. Nitrogen, phosphorous, and potassium treatments were used for deficiency conditions. Water stress was also induced in test plants. Reflectance spectra were obtained in the visible and near infrared (400nm to 2600nm) wavebands. Numerous effects of stress conditions can be observed in the collected spectra and this technique appears to have promise as a remote monitor of plant health, but significant research remains to be conducted to realize the promise. Author (revised by Herner)

A95-93784
MACHINE VISION MONITORING OF PLANT HEALTH
A. HETZRONI Purdue University, West Lafayette, Indiana, US, G. E. MILES Purdue University, West Lafayette, Indiana, US, B. A. ENGEL Purdue University, West Lafayette, Indiana, US, P. A. HAMMER Purdue University, West Lafayette, Indiana, US, and R. X. LATIN Purdue University, West Lafayette, Indiana, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)203-(11)212
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Techniques and algorithms to detect and diagnose disorders in plant growth in a controlled environment have been developed. A video camera senses features of plants which are indicative of disorders. Images are calibrated for size and color variations by using calibration templates. Different image segmentation techniques for separating object from background, have been implemented. Plant size and color properties have been investigated, temporal, spectral and spatial variation of leaves were extracted from the segmented images. Neural network and statistical clasifiers were used to determine plant condition. Author (revised by Herner)

A95-93785
A ROOT MOISTURE SENSOR FOR PLANTS IN MICROGRAVITY
G. J. CLARK University of Florida, Gainesville, Florida, US, G. E. NEVILLE University of Florida, Gainesville, Florida, US, and T. W. DRESCHEL The Bionetics Corporation, Florida, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)213-(11)216
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Development of components for bioregenerative life-support systems is a vital step toward long-term space exploration. The culturing of plants in a microgravity environment may be optimized by the use of appropriate sensors and controllers. This paper describes a sensor developed for determining the amount of fluid (nutrient solution) available on the surface of a porous ceramic nutrient delivery substrate to the roots of conventional crop plants. The sensor is based on the change in thermal capacitance and thermal conductance near the surface as the moisture content changes. The sensor could be employed as a data acquisition and control sensor to support the automated monitoring of plants grown in a microgravity environment. Author (revised by Herner)

A95-93786
NOVEL SENSOR TECHNOLOGY FOR MONITORING AND CONTROL OF CRITICAL PLANT NUTRIENT PARAMETERS
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A novel dielectric sensor technology has been developed for monitoring and control of plant nutrient delivery system as part of NASA's Controlled Ecological Life Support System (CELSS) program. A unique measurement phenomenon was discovered in which the electrostatic field is shunted to a third terminal of the sensor, resulting in a much greater sensitivity to changes in the complex dielectric properties of the nutrient solution. Based on this phenomenon, a small flexible, thin-film shunting electric dielectric sensor (SDS) was designed to provide low-frequency, non-invasive measurement of both the thickness and nutrient concentration of the layer of solution on a plant growth surface. Test results indicate a sensitivity of +/- 0.05mm in layer thickness while characterization of the ability to measure nutrient concentration continues. The development plan for this sensor is presented and other applications are discussed. Author (revised by Herner)

A95-93787
OPTICAL SENSORS FOR MONITORING AND CONTROL OF PLANT GROWTH SYSTEMS
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Optical chemical sensors have been developed for monitoring several parameters relevant to plant growth systems. These sensors utilize porous polymer and porous glass as the sensing element, and optical fiber input/output lines connected to a custom optoelectronic interface. Present in the sensing element are immobilized colorimetric indicators, which react with the analyte to be sensed. This reaction results in a change in the optical properties of the sensor. These sensors are particularly suited to in-situ monitoring of nutrient solution parameters and atmospheric trace contaminants in life support and plant growth systems. Sensors for monitoring pH, ammonia, and ethylene will be discussed.
Author (revised by Herner)

A95-93788
INSTRUMENTATION FOR PLANT HEALTH AND GROWTH
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Comprehensive spectroscopic monitoring of plant health and growth in bioregenerative life support system environments is possible using a variety of spectrometric technologies. Absorption spectrometry and atomic emission spectrometry in combination allow for direct, on-line, reagentless monitoring of plant nutrients from nitrate and potassium to micronutrients such as copper and zinc. Fluorometric spectrometry is ideal for the on-line detection, identification and quantification of bacteria and fung. Liquid Atomic Emission Spectrometry (LAES) is a new form of spectrometry that allows for direct measurement of atomic emission spectra in liquids. An electric arc is generated by a pair of electrodes in the liquid to provide the energy necessary to break molecular bonds and reduce the substance to atomic form. With a fiber probe attached to the electrodes, spectral light can be transmitted to a photodiode array spectrometer for light dispersion and analysis. Ultraviolet (UV) aborption spectrometry is a long-established technology, but applications typically have required specific reagents to produce an analyte-specific absorption. Nitrate and iron nutrients have native UV abosrption spectra that have been used to accurately determine nutrient concentrations at the +/- 5% level. Fluorescence detection and characterization of mirobes is based upon the native fluorescent signatures of most microbiological species. Spectral and time-resolved fluorometers operating with

remote fiber-optic probes will be used for on-line microbial monitoring in plant nutrient streams. Author (revised by Herner)

A95-93789
MEASUREMENT OF RICE CROP METABOLISM USING CLOSED-TYPE PLANT CULTIVATION EQUIPMENT
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Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)237-(11)240

In order to determine a required plant cultivation area which can sustain human life in a closed environment, the material circulating measurement system including a Closed-type Plant Cultivation Equipment (CPCE) in which the metabolic data of plants can be accurately measured has been constructed. According to results from cultivation experiments using rice, the harvest index was 29.9% for 110 days, and the required crop area to supply food, oxygen and water for one person was calculated to be about 111 sq m, 36 sq m and 0.9 sq m, respectively.
Author (revised by Herner)

A95-93790
CARBON DIOXIDE INTERACTIONS WITH IRRADIANCE AND TERMPERATURE IN POTATOES
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Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)243-(11)250

Separate controlled environment studies were conducted to determine the interaction of CO2 with irradiance and interaction of CO2 with temperature on growth of three potato cultivars. In the first study, an elevated CO2 concentration of 100 micromol/mol and an ambient CO2 of 350 micromol/mol were maintained at the photosynthetic photon fluxes (PPF) of 17 and 34 mol sq m/d with 12 h photoperiod, and at the PPF of 34 and 68 mol sq m/d with 24 h photoperiod. Tuber and total dry weights of 90-day old potatoes were significantly increased with CO2 enrichemnt, but the CO2 stimulation was less with higher PPF and longer photoperiod. Shoot dry weight was affected more by photoperiod than by PPF and CO2 concentrations. The elevated CO2 concentration increased leaf CO2 assimilation rates and decreased stomatal conductance with 12 h photoperiod, but had only a marginal effect with 24 h photoperiod. In the second study, four CO2 concentrations of 500, 1000, 1500 and 2000 micromol/mol were combined with two air temperature regimes of 16 and 20 C under a 12 h photoperiod. At harvest, 35 days after transplanting, tuber and total dry weights of potatoes reached a maximum with 1000 micromol/mol CO2 at 16 C, but continued to increase up to 2000 micromol/mol CO2 at 20 C. This suggests a carbohydrate build-up in the leaves at 16 C temperature that reduces plant response to increased CO2 concentrations. The data in the two studies indicate that a PPF of 34 mol sq m/d, 20 C temperature, and 1000-2000 micromol/mol CO2 produces optimal tuber yield in potatoes.
Author (revised by Herner)

A95-93791
GROWTH OF SOYBEAN AND POTATO AT HIGH CO2 PARTIAL PRESSURES
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Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)251-(11)255

Soybean and potato plants were grown in controlled environments at carbon dioxide (CO2) partial pressures ranging from 0.05 to 1.00 kPa. The highest yields of edible biomass occurred at 0.10 kPa for both species, with higher CO2 levels being supraoptimal, but not injurious to the plants. Stomatal conductance rates of upper canopy leaves were lowest at 0.010 kPa CO2, while conductance rates at 0.50 and 1.00 kPa were significantly greater than 0.010 kPa. Total water use by the plants was greatest at the highest CO2 pressures (i.e. 0.50 and 1.00 kPa); consequently, water use efficiencies (biomass produced/water used) were low at the highest CO2 pressures. Based on previous CO2 studies in the literature, the increased conductance and water use at the highest CO2 pressures were surprising and pose interesting challenges for managing plants in a Controlled Ecological Life Support Systems (CELSS), where CO2 pressures may exceed optimal levels.
Author (revised by Herner)

A95-93792
CO2 CROP GROWTH ENHANCEMENT AND TOXICITY IN WHEAT AND RICE
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Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)257-(11)267

The effects of elevated CO2 on plant growth are reviewed and the implications for crop yields in regenerative systems are discussed. There is considerable theoretical and experimental evidence indicating that the beneficial effects of CO2 are saturated at about 0.12% CO2 in air. However, CO2 can easily rise as high as 2%. Elevating CO2 from 340 to 1200 micromol/mol can increase the seed yield of wheat and rice by 30 to 40%; unfortunately, further CO2 elevation to 2500 micromol/mol (0.25%) has consistently reduced yield by 25% compared to plants grown at 1200 micromol/mol; fortunately, there was only an additional 10% decrease in yield as the CO2 level was further elevated to 2% (20,000 micromol/mol). Yield increases in both rice and wheat were primarily the result of increased number of heads per sq m, with minor effects on seed number per head and seed size. Yield increases were greatest in the highest photosynthetic photon flux. We used photosynthetic gas exchange to analyze CO2 effects on radiation interception, canopy quantum yield, and canopy carbon use efficiency. We were surprised to find that radiation interception during early growth was not improved by elevated CO2. As expected, CO2 increased quantum yield, but there was also a small increase in carbon use efficiency. Super-optimal CO2 levels did not reduce vegetative growth, but decreased seed set and thus yield. The reduced seed set is not visually apparent until final yield is measured. The physiological mechanism underlying CO2 toxicity is not yet known, but elevated CO2 levels (0.1 to 1% CO2) increase ethylene synthesis in some plants and ethylene is a potent inhibitor of seed set in wheat.
Author (revised by Herner)

A95-93793
SPECIFIC EFFECTS OF IRRADIANCE AND CO2 CONCENTRATION DOUBLINGS ON PRODUCTIVITY AND MINERAL CONTENT IN LETTUCE
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D'ALETTO Centre d'Etudes de Cadarache, France, and M. ANDRE Centre d'Etudes de Cadarache, France Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)269-(11)275 Research sponsored by Centre National d'Etudes Spatiales, France
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Experiments in growth chambers with controlled atmosphere were performed to compare the effects on the productivity of two treatments stimulating photosynthesis: the doubling of CO2 concentration, the doubling of irradiance; the combining of both was also tested. A large effect of light was noticed: (1) the accumulation of carbon was, contrarily to CO2 effect, amplified within time, and led to the most important dry matter production; (2) the specific leaf weight was about two-fold increased; (3) the nitrate content was 2-3 fold less. A significant positive effect of CO2 was detected on the fresh biomass production and the iron content of lettuce. A synergy was observed on dry matter production by the interaction of the two factors. Author (revised by Herner)

A95-93794* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
EFFECTS OF SEVERAL ENVIRONMENTAL FACTORS ON SWEETPOTATO GROWTH
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Effects of relative humidity, light intensity and photoperiod on growth of 'Ga Jet' and TI-155' sweetpotato cultivars, using the nutrient film technique (NFT), have been reported. In this study, the effect of ambient temperature regimes (constant 28 C and diurnal 28:222 C day:night) and different CO2 levels (ambient, 400, 1 000 and 10 000 microL/L-400, 1 000 and 10 000 ppm) on growth of one or both of these cultivars in NFT are reported. For a 24-h photoperiod, no storage roots were prodcued for either cultivar in NFT when sweetpotato plants were grown at a constant temperature of 28 C. For the same photoperiod, when a 28:22 C diurnal temperature variation was used, there were still no storage roots for 'TI-155' but the cv. 'Ga Jet' produced 537 g/plant of storage roots. For both a 12-h and 24-h photoperiod. 'Ga Jet' storage root fresh and dry weight tended to be higher with a 28:22 C diurnal temperature variation than with a constant 28 C temperature regime. Preliminary results with both 'Ga Jet' and 'TI-155' cultivars indicate a distinctive diurnal stomatal response for sweetpotato grown in NFT under an ambient CO2 level. The stomatal conductance values observed for 'Ga Jet' at elevated CO2 levels indicated that the difference between the light- and dark-period conductance rates persisted at 400, 1 000, and 10 000 microL/L. Author (revised by Herner)

A95-93795
PLANT GROWTH AND GAS BALANCE IN A PLANT AND MUSHROOM CULTIVATION SYSTEM
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In order to obtain basic data for construction of a plant cultivation system incorporating a mushroom cultivation system in the Controlled Ecological Life Support System (CELSS), plant growth and atmospheric CO2 balance in the system were investigated. The plant growth was promoted by a high level of CO2 which resulted from the respiration of the mushroom mycelium in the system. The atmospheric CO2 concentration inside the system changed significantly due to the slight change in the net photosynthetic rate of plants and/or the respiration rate of the mushroom when the plant cultivation system combined directly with the mushroom cultivation system. Author (revised by Herner)

A95-93796 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ELEVATED CO2: IMPACT ON DIURNAL PATTERNS OF PHOTOSYNTHESIS IN NATURAL MICROBIAL ECOSYSTEMS
L. J. ROTHSCHILD NASA-Ames Research Center, Moffett Field, California, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)285-(11)289
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Algae, including blue-green algae (cyanobacteria), are the major source of fixed carbon in many aquatic ecosystems. Previous work has shown that photosynthetic carbon fixation is often enhanced in the presence of additional carbon dioxide (CO2). This study was undertaken to determine if this CO2 fertilization effect extended to microbial mats, and, if so, at what times during the day might the addition of CO2 affect carbon fixation. Four microbial mats from diverse environments were selected, including mats from a hypersaline pond (area 5, Exportadora de Sal, Mexico), the marine intertidal (Lyngbya, Laguna Ojo de Liebre, Mexico), an acidic hotspring (Cyanidium, Nymph Creek, Yellowstone National Park), and an acidic stream at ambient temperature (Zygogonium, Yellowstone National Park). Carbon fixation in the absence of additional CO2 essentially followed the rising and falling sunlight levels, except that during the middle of the day there was a short dip in carbon fixation rates. The addition of CO2 profoundly enhanced carbon fixation rates during the daylight hours, including during the midday dip. Therefore, it is unlikely that the midday dip was due to photoinhibition. Surprisingly, enhancement of carbon fixation was often greatest in the early morning or late afternoon, times when carbon fixation would be most likely to be light limited. Author (revised by Herner)

A95-93800
ECOSIMP2 MODEL: PREDICTION OF CO2 CONCENTRATION CHANGES AND CARBON STATUS IN CLOSED ECOSYSTEMS
M. ANDRE Cnetre d'Etudes de Cadarache, France, J. THIERY Cnetre d'Etudes de Cadarache, France, and L. COURNAC Cnetre d'Etudes de Cadarache, France Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)323-(11)326
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The ECOSIMP 2 model, simulating the Plant-Soil-Atmosphere interactions, was developed as a tool for the management of an experimental artificial ecosystem. It consists in three main carbon compartments for production, consumption and decomposition of the biomass. The main biological parameters concern photosynthesis (apparent Km, CO2 compensation point), the harvest index, the rate of consumption, and the kinetics of litter decomposition. From realistic assumptions of kinetics of soil compartments, a steady-

state case was obtained, simulating a terrestrial ecosystem. The stability of the atmospheric CO2 concentration was studied after a virtual enclosure of the system in a 20-m high greenhouse. In natural lighting the conditions of stability are severe because of the small size of the atmospheric compartment which amplifies any imbalance between carbon fluxes. The positive consequence of that amplification for research on artifical ecosystems was emphasized.
Author (revised by Herner)

A95-93803* National Aeronautics and Space Administration, Washington, DC.
MODELING GAS EXCHANGE IN A CLOSED PLANT GROWTH CHAMBER
J. D. CORNETT Colorado State University, Fort Collins, Colorado, US, J. E. HENDRIX Colorado State University, Fort Collins, Colorado, US, R. M. WHEELER NASA Biological Research and Life Support Office, Cocoa Beach, Florida, US, C. W. ROSS Colorado State University, Fort Collins, Colorado, US, and W. Z. SADEH Colorado State University, Fort Collins, Colorado, US *Life sciences and space* research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)337-(11)341
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Fluid transport models for fluxes of water vapor and CO2 have been developed for one crop of wheat and three crops of soybean grown in a closed plant growth chamber. Correspondence among these fluxes is discussed. Maximum fluxes of gases are provided for engineering design requirements of fluid recycling equipment in growth chambers. Furthermore, to investigate the feasibility of generalized crop models, dimensionless representations of water vapor fluxes are presented. The feasibility of such generalized models and the need for additional data are discussed.
Author (revised by Herner)

A95-93804
'SVET' SPACE GREENHOUSE ONBOARD EXPERIMENT DATA RECEIVED FROM 'MIR' STATION AND FUTURE PROSPECTS
T. IVANOVA Space Research Institute, Sofia, Bulgaria, S. SAPUNOVA Space Research Institute, Sofia, Bulgaria, I. DANDOLOV Space Research Institute, Sofia, Bulgaria, Y. IVANON Space Research Institute, Sofia, Bulgaria, G. MELESHKO Institute of Biomedical Problems, Moscow, Russia, A. MASHISKY Institute of Biomedical Problems, Moscow, Russia, and Y. BERKOVICH Institute of Biomedical Problems, Moscow, Russia Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)343-(11)346
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The paper describes operation of 'SVET' space greenhouse onboard the 'MIR' orbital station since 15 June 1990 and the adapted biotechnological principles. The microprocessor and measuring systems for monitoring and control of the environmental parameters in the Plants growth chamber are presented. Information about the dynamic of these parameters in the course of the first space experiments with vegetables, obtained by means of telemetric data processing, is given. A draft program for the development of next generations of greenhouses of the same type as 'SVET', but with a larger area and capabilities, is worked out. Author (revised by Herner)

A95-93805
IDENTIFICATION AND ORIGIN OF PLANT PATHOGENIC MICROORGANISMS IN RECIRCULATING NUTRIENT SOLUTIONS
M. E. STANGHELLINI University of Arizona, Tuscon, Arizona, US and S. L. RASMUSSEN University of Arizona, Tuscon, Arizona, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)349-(11)355
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Avoidance of root-infecting microorganisms was originally considered one of the advantages of cultivation of crops in a soilless, recirculating nutrient solution. However, to date, four viral, three bacteraial and 21 fungal pathogens have been identified as casual agents of root disease in hydroponically-grown crops. Root-infecting fungi, particularly those which produce a motile stage known as zoospore, have been the primary pathogens associated with extensive crop losses. Documented sources of these root pathogens in hydroponic systems include peat, surface water such as rivers and streams, and insects. The severity of disease caused by these introduced root pathogens is primarily governed by the genetic susceptibility of each crop and the temperature of the recirculating nutrient solution. Author (revised by Herner)

A95-93806
***DYNAMICS OF MICROORGANISM POPULATIONS IN* RECIRCULATING NUTRIENT SOLUTIONS**
R. F. STRAYER NASA Biomedical Operations and Research Office, Cocoa Beach, Florida, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)357-(11)366
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This overview covers the basic microbial ecology of recirculating hydroponic solutions. Examples from NASA and Soviet Controlled Ecological Life Support Systems (CELSS) tests and the commercial hydroponic industry will be used. The sources of microorganisms in nutrient solutions include air, water, seeds, plant containers and plumbing, biological vectors, and personnel. Microbial fates include growth, death, and emigration. Important microbial habitats within nutrient delivery systems are root surfaces, hardware surfaces (biofilms), and solution suspension. Numbers of bacteria on root surfaces usually exceed those from the other habitats by several orders of magnitude. Gram negative bacteria dominate the microflora with fungal counts usually much lower. Trends typically show a decrease in counts with increasing time unless stressed plants increase root exudates. Important microbial activities include carbon mineralization and nitrogen transformations. Important detrimental interactions include competition with plants, and human and plant pathogenesis. Author (revised by Herner)

A95-93807
CONTROL OF MICROORGANISMS IN FLOWING NUTRIENT SOLUTIONS
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Controlling microorganisms in flowing nutrient solutions involves different techniques when targeting the nutrient solution, hardware surfaces in contact with the solution, or the active root zone. This review presents basic principles and applications of a number of treatment techniques, including disinfection by chemicals, ultrafiltration, ultrasonic heat treatment, with emphasis on UV irradiation and ozone treatment. Procedures for control of specific pathogens by nutrient solution condition are also reviewed.
Author (revised by Herner)

A95-93809
THE STRUCTURE AND FUNCTION OF MICROBIAL COMMUNITIES IN RECIRCULATING HYDROPONIC SYSTEMS
J. L. GARLAND The Bionetics Corporation, Cocoa Beach, Florida, US Life sciences and space research 25 (3): Natural and artificial

ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)383-(11)386
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Strategies to control the microbial community associated with plant growth systems need to be based on a fundamental understanding of the factors which structure and regulate the community. Spatial and temporal patterns in the abundance and production rate of microorganisms in hydroponic systems containing wheat were examned to evaluate how root-derived carbon is processed. The relevance of results to monitoring and control strategies is discussed. Author (revised by Herner)

A95-93810
ESTABLISHING AND MAINTAINING SPECIFIC PATHOGEN FREE (SPF) CONDITIONS IN AQUEOUS SOLUTIONS USING OZONE
B. VESTERGARD BV Hydro Systems, Taastrup, Denmark Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)387-(11)393
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The paper discusses the use of ozone in space applications for the elimination of pathogens, and the enhancement of the oxidation potential of ozone using hydrogen peroxide and ultraviolet radiation. These combinations will be possible to set up in space conditions. The sterilizing effect versus free radical generation is an important equilibrium to establish when specific pathogen free conditions are wanted in aqueous solutions containing organic matter. In situ sterilization of plant roots in hydroponic systems, as well as the oxidation of root exudates, will be discussed. The paper will contain examples of the chemical interaction of ozone with some of the other compounds found in hydroponic systems.
Author (revised by Herner)

A95-93811
SPECTRAL QUALITY MAY BE USED TO ALTER PLANT DISEASE DEVELOPMENT IN CELSS
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Plants were grown under light emitting diode (LED) arrays with different spectral qualitites to determine the effects of light on the development of tomato mosaic virus (ToMV) in peppers and powdery mildew on cucumbers. One LED array supplied 100% of the pothosynthetic photon flux (PPF) at 660 nm, a second array supplied 90% of the PPF at 660 nm and 10% at 735 nm, and a third array supplied 98% of the PPF at 660 nm with 2% in the blue region (380-500 nm) supplied by blue fluroescent lamps. Control plants were grown under metal halide (MH) lamps. Pepper plants inoculated with ToMV and grown under 660 and 660/735 LED arrays showed marked increases in both the rate and the severity of symptoms as compared to inoculated plants grown under the MH lamp or 660/blue array. Pepper plants grown under the 660/blue array did not develop symptoms as rapidly as inoculated plants grown under the 660 or 660/735 arrays, but they did develop symptoms faster than inoculated plants grown under the MH lamp. The numbers of colonies of powdery mildew per leaf and the size of each colony were greatest on inoculated cucumber plants grown under the MH lamp.
Author (revised by Herner)

A95-93813
USE OF PLANETARY SOILS WITHIN CELSS: THE PLANT VIEWPOINT
L. ART SPOMER University of Illinois, Urbana, Illinois, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)411-(11)416
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The major functions of soil relative to plant growth include retention and supply of water and minerals, provision of anchorage and support for the root, and provision of an otherwise adequatge physical and chemical environment to ensure an extensive, functioning root system. The phsycial and chemical nature of the solid matrix constituting a soil interacts with the soil confinement configuration, the growing environment, and plant requirements to determine the soil's suitability for plant growth. A wide range of natural and manufactured terrestrial materials have proved adequate soils provided they are not chemically harmful to plants (or animals eating the plants), are suitably prepared for the specific use, and are used in a compatible confinement system. It is presumed this same rationale can be applied to planetary soils for growing plants within any controlled environment life support system (CELSS). The basic concepts of soil and soil-plant interactions are reviewed relative to using soils constituted from local planetary materials for growing plants. Author (revised by Herner)

A95-93815
SOLID MATRIX AND LIQUID CULTURE PROCEDURES FOR GROWTH OF POTATOES
T. W. TIBBITTS University of Wisconsin, Madison, Wisconsin, US and W. CAO University of Wisconsin, Madison, Wisconsin, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)427-(11)433
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This report discusses the advantages and limitations of several different procedures for growth of potatoes for Controlled Ecological Life Support System (CELSS). Solution culture, in which roots and stolons are submerged, and aeroponic culture were not found useful for potatoes because stolons did not produce tubers unless a severe stress was applied to the plants. In detailed comparison studies, three selected culture systems were compared, nutrient film technique (NFT), NFT with shallow media, and pot culture with deep media. For the NFT and NFT plus shallow media, plants were grown in 0.3 sq m trays and for the deep medium culture, in 20 liter pots. A 1 cm depth of arcillite, a baked montmorillonite clay, was used as shallow media (NFT-arc). Peat-vermiculite mixture was used to fill the pots for the deep media. Nutrient solution, modified half-strength Hoagland's, was recirculated among the tray culture plants with pH automatically controlled at 5.5, and conductivity maintained at approximately 110 microS/cm by adding stock nutrients or renewing the solution. A separate nutrient solution was used to water the pot plants four times daily to excess and the excess was discarded. Plants of Norland cv. were utilized and transplanted from sterile-propagated stem cutting plantlets. The plants were grown for 66 days under 12 h photoperiod in a first study and grown for 54 days under 24 h photoperiod in a second study. Under both photoperiods, total plant growth was greater in NFT-arc than in either NFT or pot culture. Under 12 h photoperiod, tuber dry weight was 30% higher with NFT-arc, but 50% lower with NFT, than with pot culture. Under 24 h photoperiod, however, tuber dry weight in both NFT and NFT-arc was only 20% of that in pot culture. The NFT and NFT-arc produced a greater shoot growth and larger number of small tubers than pot culture, especially with 24 h photoperiod. It is concluded that there are serious limitations to the use of NFT alone for growth of potatoes in a CELSS system. These limitations can be minimized by using a modified NFT with a shallow layer of media, such as arcillite, yet additional work is needed to ensure high tuber production with this system under long photoperiods. Author (revised by Herner)

A95-93816 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
USE OF LUNAR REGOLITH AS A SUBSTRATE FOR PLANT GROWTH
D. W. MING NASA Johnson Space Center, Houston, Texas, US and D. L. HENNINGER NASA Johnson Space Center, Houston, Texas, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)435-(11)443
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Regenerative Life Support Systems (RLSS) will be required to regenerate air, water, and wastes, and to produce food for human consumption during long-duration missions to the Moon and Mars. It may be possible to supplement some of the materials needed for a lunar RLSS from resources on the Moon. Natural materials at the lunar surface may be used for a variety of lunar RLSS needs, including (1) soils or solid-support substrates for plant growth, (2) sources for extraction of essential, plant-growth nutrients, (3) substrates for microbial populations in the degradation of wastes, (4) sources of O2 and H2, which may be used to manufacture water, (5) feed stock materials for the synthesis of useful minerals (e.g., molecular sieves), and (6) shielding materials surrounding the outpost structure to protect humans, plants, and microorganisms from harmful radiation. Use of indigenous lunar regolith as a terrestrial-like soil for plant growth could offer a solid support substrate, buffering capacity, nutrient source/storage/retention capabilities, and should be relatively easy to maintain. The lunar regolith could, with a suitable microbial population, play a role in waste renovation; much like terrestrial waste application directly on soils. Issues associated with potentially toxic elements, pH, nutrient availability, air and fluid movement parameters, and cation exchange capacity of lunar regolith need to be addressed before lunar materials can be used effectively as soils for plant growth.

Author (revised by Herner)

A95-94877
FORWARD AND INVERSE PROBLEMS IN ELASTICITY IMAGING OF SOFT TISSUES
K. R. RAGHAVAN Univ of Michigan, Ann Arbor, MI, United States and ANDREW E. YAGLE IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1639-1645 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424675) Copyright

In elasticity imaging, a surface deformation is applied to an object using small pistons, and the resulting induced strains in the interior of the object are measured using ultrasonic imaging. Two important problems are considered: (1) the forward problem of determining the strains induced by a known deformation of an object with known elasticity; and (2) the inverse problem of reconstructing elasticity from measured strains and the equations of equilibrium. The method of finite differences is used to solve the forward problem for a given piston configuration; some non-trivial issues arise in determining boundary conditions. The finite difference equations are then rearranged into a linear system of equations which formulates the inverse problem; this system can be solved for the unknown elasticities. This formulation of the inverse problem is completely consistent with the forward problem; this is useful for iterative methods in which the deformation is adaptively changed. A comparison between simulated and actual measured results demonstrate the feasibility of the proposed procedure. Author (EI)

A95-94880
USING SIMULTANEOUS TRANSMISSION AND SCATTER SPECT IMAGING FROM EXTERNAL SOURCES FOR THE DETERMINATION OF THE THORACIC MU -MAP
SRECKO LONCARIC Rush Presbyterian - St. Luke's Medical Cent, Chicago, IL, United States, WEI CHANG, and GANG HUANG IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1601-1606 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424669) Copyright

We describe a new technique that uses simultaneous transmission and scatter SPECT imaging for determination of segmented attenuation mu -maps. These mu -maps could provide the basis for attenuation correction and quantification of radiopharmaceutical uptake in cardiac SPECT. For transmission imaging, a line source and a fan-beam collimator on one head of a triple-head SPECT system are used. For scatter imaging, two external ring sources and parallel collimators on one or two of the other heads are used. The fan-beam transmission data are truncated, while the parallel-beam data are not. The proposed technique uses both sets of tomographic data to complement each other and to obtain a composite image. A mu -map with three segmented regions of distinct mu -values could be derived from the composite image. This final mu -map can then be used as the basis for attenuation correction. *Author (EI)*

A95-94881
SCATTER MODEL FOR PARALLEL AND CONVERGING BEAM SPECT BASED ON THE KLEIN-NISHINA FORMULA
Z.-J. CAO Univ of North Carolina, Chapel Hill, NC, United States, E. C. FREY, and B. M. W. TSUI IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1594-1600 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424668) Copyright

In this study, a scatter model is proposed for parallel-, fan-, and cone-beam SPECT imaging. In this model, a photon is allowed to be scattered only once, and the probability of scatter for given angle and energy is computed by using the Klein-Nishina formula. The detector is assumed to have perfect energy resolution. The scatter counts are computed for every projection bin. From the scatter counts, the scatter line source response function and scatter-to-primary ratio (SPR) are obtained. They agree well with those from Monte Carlo (MC) simulation including only single scattering, but deviate from those from full MC simulation including both single and multiple scattering. The deviation depends on the source depth within the medium. For a source depth of 6 cm, the difference of the scatter-to-primary ratio between the model and full MC simulation is less than 7%, while for a 21.6 cm source depth, the difference goes up to 27% for parallel-beam geometry and 32% for cone-beam geometry. Since scatter accounts for 20-40% of the total counts in most clinical studies, the scatter model yields a SPR accuracy that ranges from 3% to 12%. The scatter model provides an effective means to estimate the scatter response with reasonable accuracy, and can be used in developing scatter compensation techniques in parallel- and converging-beam SPECT. Author (EI)

A95-94884
CHARACTERIZATION OF SAMPLING SCHEMES FOR WHOLE BODY PET IMAGING
M. DAHLBOM UCLA Sch of Medicine, Los Angeles, CA, United States, P. D. CUTLER, W. M. DIGBY, W. K. LUK, and J. REED IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1571-1576 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424665) Copyright

Whole body PET images suffer from relatively high noise levels due to inherently poor counting statistics in the emission data. Optimization of acquisition parameters is essential, to minimize any additional noise contamination. It has previously been shown that by using a continuous or redundant axial sampling scheme, a reduction in statistical noise and improvement in image quality are possible. In this work, the continuous axial sampling technique is further characterized and compared to the conventional step-and-shoot technique. The main source of additional noise contamination with

conventional sampling is the detector sensitivity normalization procedure which is applied to the emission data. With continuous axial sampling and a single normalization matrix for all planes, the statistical noise in the normalization factors is reduced by factor close to the number of planes in the scanner. The continuous sampling technique is shown to be less sensitive to small patient movements (less than 5 mm) compared to conventional sampling. Previously reported problems of data handling have been resolved by rewriting the acquisition firmware to allow on-line addition of the redundant sampled data in hardware. Author (EI)

A95-94885
SIMPLE DATA LOSS MODEL FOR POSITRON CAMERA SYSTEMS
LARS ERIKSSON Karolinska Hospital and Inst, Stockholm, Sweden, KLAUS WIENHARD, and MAGNUS DAHLBOM IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1566-1570 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424664) Copyright

A simple model to describe data losses in PET cameras is presented. The model is not intended to be used primarily for dead time corrections in existing scanners, although this is possible. Instead the model is intended to be used for data simulations in order to determine the figures of merit of future camera systems, based on data handling state-of-art solutions. The model assumes the data loss to be factorized into two components, one describing the detector or block-detector performance and the other the remaining data handling such as coincidence determinations, data transfer and data storage. Two modern positron camera systems have been investigated in terms of this model. These are the Siemens-CTI ECAT EXACT and ECAT EXACT HR systems, which both have an axial field-of-view (FOV) of about 15 cm. The both have retractable septa and can acquire data from the whole volume within the FOV and can reconstruct volume image data. An example is given how to use the model for live time calculations in a futuristic large axial FOV cylindrical system. Author (EI)

A95-94887
STUDY ON THE USE OF TRANSMISSION SCANS FOR WHOLE BODY PET ATTENUATION CORRECTION
A. CHATZIIOANNOU UCLA Sch of Medicine, Los Angeles, CA, United States, M. DAHLBOM, and C. K. HOH IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1545-1550 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424660) Copyright

Transmission scans for attenuation correction of whole body PET studies are not acquired routinely, since noise considerations impose acquisition time constraints that make conventional scanning techniques infeasible. The aim of this work is to optimize data acquisition and processing parameters and improve the SNR of whole body transmission scans, in order to achieve within a reasonable time frame, an attenuation correction of the same quality as in cardiac PET. Methods to improve the scanner sensitivity by using additional coincidence planes, as well as smoothing methods for the randoms and the transmission data were investigated. Phantom and patient studies show that transmission scans are feasible for whole body PET studies, with equivalent noise introduced in the chest area as in a typical cardiac PET attenuation correction, at fractions of the time required by conventional transmission scan protocols.
Author (EI)

A95-94888
EVALUATION OF POST-INJECTION TRANSMISSION MEASUREMENT IN PET
TIMOTHY G. TURKINGTON Duke Univ Medical Cent, Durham, NC, United States, R. EDWARD COLEMAN, SCOTT F. SCHUBERT, and ALEX GANIN IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1538-1544 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424659) Copyright

PET transmission scanning in the presence of emission activity has been investigated on two scanners with orbiting pin transmission sources. One phantom consisting of varying sized spherical inserts in a uniform background and another containing simulated lungs and spine, a myocardium insert, and uniform background were imaged at various emission activity levels. Insert radioactivity concentration levels varied up to 3.5 mu Ci/mL. Transmission acquisitions were performed with the phantoms aligned with the emission scan position, and with the phantoms shifted to simulate patient motion between scans. Images were reconstructed with and without compensation for the emission contamination. Qualitative and quantitative evaluation of the resulting image sets was performed. The emission correction resulted in no visible artifacts and approximately 3% quantitative accuracy. Author (EI)

A95-94889
LOCAL THRESHOLD FOR SEGMENTED ATTENUATION CORRECTION OF PET IMAGING OF THE THORAX
M. XU Mallinckrodt Inst of Radiology, St. Louis, MO, United States, W. K. LUK, P. D. CUTLER, and W. M. DIGBY IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1532-1537 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424658) Copyright

A local threshold for segmented attenuation correction technique has been developed for positron emission tomography using short (2-3 minutes) post-injection transmission scans. The technique implements an optimal threshold method on localized histograms to get pseudo-anatomic segmentation on transmission images. Theoretical values of attenuation coefficients are assigned to corresponding anatomic regions. Emission images are reconstructed using attenuation correction factors computed by forward-projecting segmented transmission images. Phantoms and clinical cardiac images are studied using this technique. The technique corrects emission images with accuracy similar to the standard, pre-injection method, reduces noise in the corrected emission images, and offers the potential for increased patient throughput by enabling shorter, post-injection data acquisition.
Author (EI)

A95-94891
SIMULATION OF IMAGING WITH SODIUM IODIDE CRYSTALS AND POSITION-SENSITIVE PHOTOMULTIPLIER TUBES
C. E. ORDONEZ Univ of Chicago, Chicago, IL, United States, R. A. MINTZER, J. N. AARSVOLD, N. J. YASILLO, and K. L. MATTHEWS IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1510-1515 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424654) Copyright

The imaging characteristics of miniature gamma cameras that consist of a single sodium iodide (NaI(Tl)) crystal coupled to a position-sensitive photomultiplier tube (PSPMT) have been studied via Monte Carlo simulations. Images obtained with such cameras with the use of conventional position calculations exhibit considerable distortions, particularly compression. This study demonstrates that the distortions result primarily from non-uniform sensitivities of PSPMTs and secondarily from non-linear responses of PSPMTs, light-reflection properties resulting from the treatments of crystals,

and light-refractive properties of glass interfaces between crystals and photocathodes. Simulation results are compared to images obtained with a prototype miniature gamma camera. Author (EI)

A95-94892
LESION DETECTABILITY CONSIDERATIONS FOR AN OPTICALLY-COUPLED CCD X-RAY IMAGING SYSTEM
HONG LIU Univ of Massachusetts Medical Cent, Worcester, MA, United States, ANDREW KARELLAS, STEPHEN C. MOORE, LISA J. HARRIS, and CARL J. D'ORSI IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1506-1509 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424653) Copyright

This project was aimed at investigating the lesion detectability of an optically-coupled CCD x-ray imaging system. The quasi-ideal observer signal-to-noise ratio (also called lesion-matched filter signal-to-noise ratio) was calculated for various clinical applications. This analysis differs from that of previous investigations in that we have analyzed jointly the effect of quantum noise and additive noise; we have also analyzed the combined effect of the contrast transfer property and the resolving power of the system. Numerical calculations were performed to determine lesion detectability and contrast-detail curves under mammographic and other clinical conditions. A standard mammographic phantom and a contrast-detail phantom were imaged to validate the calculation. The results demonstrate that the lesion detectability of a well designed optically-coupled CCD can be comparable to that of the state-of-the-art screen-film system under the same conditions. Author (EI)

A95-94900
2-DIMENSIONAL DETECTOR DECODING STUDY ON BGO ARRAYS WITH QUADRANT SHARING PHOTOMULTIPLIERS
WAI-HOI WONG Univ of Texas, Houston, TX, United States, JORGE URIBE, KERI HICKS, and MASSIMO ZAMBELLI IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1453-1457 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424644) Copyright

This is a theoretical estimation and experimental study of the positron camera detector design using quadrant sharing of phototubes and optically cross-coupled BGO scintillation crystals. This study estimates the maximum number of BGO crystals which can be coupled to a photomultiplier and be decoded with this design, based on the number of photoelectrons generated and the optical efficiency of the crystal-phototube combination. From photoelectron statistics, a 10 x 10 BGO array can be coupled to a single square phototube (Hamamatsu R-2497) and have each crystal clearly decoded. Simulation of 1-dimensional and 2-dimensional statistical photoelectron distribution verifies the estimations. The simulation also yields the optimal distribution of light to the decoding phototubes. This theoretically optimal light distribution is used to guide the development of an 8 x 8 array of 3.2 x 3.2mm BGO crystals (10mm deep) using Hamamatsu R-2497 phototubes. All 64 crystals in the array can be clearly identified. The reconstructed image resolution is further estimated for the 8 x 8 and 10 x 10 arrays. These resolution results are also compared to discrete detectors which do not use analog decoding. The comparison shows that the analog decoding process degrades the image resolution by 7 to 9%. Author (EI)

A95-94901
DESIGN AND ENGINEERING ASPECTS OF A HIGH RESOLUTION POSITRON TOMOGRAPH FOR SMALL ANIMAL IMAGING
R. LECOMTE Universite de Sherbrooke, Sherbrooke, Que, Canada, J. CADORETTE, P. RICHARD, S. RODRIGUE, and D. ROULEAU IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1446-1452 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424643) Copyright

We describe the Sherbrooke positron emission tomograph, a very high resolution device dedicated to dynamic imaging of small laboratory animals. Its distinctive features are: small discrete scintillation detectors based on avalanche photodiodes (APD) to achieve uniform, isotropic, very high spatial resolution; parallel processing for low deadtime and high count rate capability; multispectral data acquisition hardware to improve sensitivity and scatter correction; modularity to allow design flexibility and upgradability. The system implements the 'clam-shell' sampling scheme and a rotating rod transmission source. All acquisition parameters can be adjusted under computer control. Temperature stability at the detector site is ensured by the use of thermoelectric modules. The initial system consists of one layer of 256 modules (two rings of detectors) defining 3 image slices in a 118 mm diameter by 10.5 mm thick field. The axial field can be extended to 50 mm using 4 layers of modules (8 rings of detectors). The design constraints and engineering aspects of an APD-based PET scanner are reviewed and preliminary results are reported. Author (EI)

A95-95617
EFFECT OF SPACE CONDITIONS ON THE SUPEROXIDE DISMUTASE AND OTHER ENZYMES FROM B. SUBTILIS
SHIFANG JIA Academia Sinica, Beijing, China, JI XU, XINGHUA GUO, ZHIHENG LIU, and JISHENG RUAN Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 12-14 In CHINESE
(HTN-95-93116) Copyright

Bacillus subtilis 314 strain, a producer of superoxide dismutase (SOD) was carried into space by the recoverable satellite on October 6-13 1992. The gene for SOD of this strain was mutagenized in space. Some of the mutants showed an increase in SOD activity. While others showed a reduction. SOD produced by one of the mutants was about 1260 units/g cell after flight, while SOD produced by the control was 560 units/g cell. Test strain grew faster than control, and its survival rate after flight was approximately 10%. The activity of proteinase and amylase of the test strain were similar to that of the control strain. The results suggested that mutation caused by the space conditions could be used for industrial production.
Author (Hemer)

A95-95618
SUPPRESSION OF THE CROSSTERM IN WIGNER DISTRIBUTION BY AMBIGUITY FUNCTION AND ITS APPLICATION TO HEART SOUND SIGNAL ANALYSIS
LING ZHENG Tsinghua University, Beijing, China, CHANGHONG SONG, XIAORONG GAO, and FUSHENG YANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 15-22 In CHINESE
(HTN-95-93117) Copyright

Wigner distribution is an effective joint time - frequency representation of signals which shows many prominent properties for nonstationary signal analysis. The main obstacle for its widespread application is the interference caused by crossterms, because it is not a linear transform. Basing on the fact that Wigner Distribution WD (t,omega) and Ambiguity Function AF(xi,tau) are a two-dimensional Fourier Transform pair and that the crossterms appear in the t-omega plane as high spatial frequency fluctuations, it is proposed in this paper that the crossterm may be suppressed by 'low pass filtering' the Ambiguity Function in (xi,tau) plane and then inverse transformed to the (t,omega) plane. The validity of the proposed method was verified by computer simulation. It was also applied to the analysis of heart sound and some interesting initial results were obtained. Author (Hemer)

A95-95622
SHORT-TERM TEST OF DICHLOROMETHANE TOXICITY IN CLOSED SPACE
QINGXIANG YU Institute of Space Medico, Beijing, China, HENGTAI ZHANG, XIUYING LI, and YONGJIA WEI Space Medicine &

Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 37-41 In CHINESE
(HTN-95-93121) Copyright

Eighty-four male kunming mice (20-23 grams) supplied by Animal Center of Chinese Academy of Medical Sciences served as subjects. Mice were divided into exposure group, control group in-cabin and control group out-cabin. During the test, the concentration of dichloromethane gas in cabin was monitored by a Shimatzu Gas Chromatograph (GC-7AG). The concentrations of oxygen and carbon dioxide in the cabin was supervised by a San-Ei Expired Gas Monitor (Model 1H21A). Mice were exposed to different concentrations of dichloromethane gas for 8 days and nights in closed space of the cabin. The results showed that the closed space of the cabin alone had no effect on mice. While inhalation of dichloromethane caused increase in organ relative weight of heart, liver and lungs but decrease of that of kidney. There were bubble like changes in the hepatic cells and granulous changes in the cardiac muscles. Dichloromethane poisoning caused atrophy of immune organ and decrease of peripheral T-lymphatic cells and immunoglobulin M plaque forming cells (IgM PFC). The changes were statistically significant and showed distinct concentration-effect relationship.
Author (Hemer)

A95-95623
EFFECTS OF LARGE DOSE VITAMIN C ON THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF FEMURA IN TAIL-SUSPENDED RATS

SHUMIN BAI Institute of Space Medico, Beijing, China, CHENLIN LIU, SHILIANG SHEN, and JING ZHANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 42-45 In CHINESE
(HTN-95-93122) Copyright

Effects of large dose vitamin C on physical and chemical characteristics of femura were studied in male S.D. rats during 22 d tail-suspension simulated weightlessness. 250 mg/kg wt of vitamin C was given to rats through tube-feeding once a day for 22 d. Physical and chemical indices and biomechanical parameters of femura and femural cartilage were examined. The results showed that hydroxyproline and ash contents, and density value of femura cartilage, the values of femura elastic loading, maximum stress and stiffness in rats supplemented with vitamin C were significantly higher than those in control rats. The results suggest that supplementation of large dose vitamin C can improve physical and chemical properties of femural cartilage, and biomechanical characteristics of femura in rats under simulated weightlessness. Author (Hemer)

A95-95624
A STUDY ON CHANGES OF GLYCOSAMINOGLYCAN AND MINERALS IN CALVARIAE AND VERTEBRAE IN RATS AFTER EXPOSURE TO SIMULATED WEIGHTLESSNESS

WEI CUI Institute of Space Medico, Beijing, China and ZHIZHEN SHI Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 46-48 In CHINESE
(HTN-95-93123) Copyright

Changes of glycosaminoglycan (GAG) and minerals in calvariae and vertebrae were observed in rats after exposure to simulated weightlessness for 21 days. The results showed that total GAG and keratosulfate contents in calvariae were decreased. Total GAG, chondroitin sulfate and collagen contents of the sixth thoracic vertebra were increased, while the mineral contents were increased to some extent. Chondroitin sulfate content of the third lumbar vertebra was increased, but mineral content was decreased. The results suggest that different bones response differently to simulated weightlessness and there is a redistribution of bone minerals.
Author (Hemer)

A95-95625
ALTERATIONS OF GASTRIN, SOMATOSTATIN, SEROTONIN AND CHROMOGRANIN A IMMUNOREACTIVE CELLS IN GASTRIC ANTRUM OF TAIL SUSPENDED RATS

RUIAN WANG The 4th Military Medical University, Xi'an, China, WENQIN CAI, HUICI SU, LIFAN ZHANG, and ZHAOPING DING Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 49-52 In CHINESE
(HTN-95-93124) Copyright

In this study, changes of serotonin(5-HT), gastrin(Gas), somatostatin (SS) and chromogranin A (CgA) immunoreactive cells in the antrum of the stomach of rat under 90 day tail suspension were observed by using ABC immunostaining technique combined with image analysis method. Altogether 20 male Wistar rats were used. They were paired and divided into two groups. One group for ground-based weightlessness simulation and another for normal control. The rats used for ground-based weightlessness simulation were suspended by the tail in head-down position with hind limbs bearing no weight for 90 days. Food and water were supplied freely. The control rats were treated as same as the experimental rats except suspension. Animals were sacrificed by over dose pentobarbital. The gastric antrums were taken out and fixed in Bouin's solution for 18 hr, then made into paraffin sections. ABC immunostaining were conducted. The results were analyzed by counting the immunopositive cell densities (cell number/mm mucosa) and measuring the positive cell grey levels with image analyzer. It was found that the 5-HT like immunoreactive (5-HT-IR) cells and Gas-immunoreactive (Gas-IR) cells in the tail-suspended rats were increased by 41% and 37% respectively, their grey levels increased by 33% and 40% respectively. However, the SS-IR cells and CgA-IR cells decreased by 21% and 25% respectively, their grey levels decreased by 28% and 12% respectively. The results indicate a shift of endocrine balance in the gastric anturm of rats under simulated weightlessness. Author (Hemer)

A95-95626
EXPERIMENTS ON MICE DURING THE EARTH ORBITAL FLIGHT IN CHINA

JINGXUE ZHANG Institute of Space Medico, Beijing, China, YUEYING XUE, YUQING WANG, JINKANG QIAN, and SHILIANG SHEN Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 53-56 In CHINESE
(HTN-95-93125) Copyright

Biological effects of orbital flight factors were studies with two mice in a biomedical chamber onboard the first recoverable satellite of China. The two healthy kunming mice survived for 5.4 days on the orbit. After a flight of 8 days, it was found that there was no significant change in the physical characteristics of the bone. Some residual cellular and blood vessels changes were found in brain and lung tissues. These changes might be considered to be occured before the death of the animals, and were probably related to the weightless condition. The death of the animals might be due to environmental pollution in the animal chamber. Author (Hemer)

A95-95627
ABSORPTION OF ULTRA-SHORT WAVE RADIANT ENERGY BY WHITE RATS

PEIJI XU Institute of Space Medico, Beijing, China, JIANMIN WU, and ZHENYU WANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 57-59 In CHINESE
(HTN-95-93126) Copyright

Body surface temperature changes of 30 white adult wistar rats exposed to ultra-short electromagnetic wave under three experimental conditions were observed with infrared hot map. The main purpose of the present study is to reveal the hazard of ultra-short wave to the organisms in order to provide necessary data for working out a related safety standard. The results showed that the temperature changes on rat's body surface are obviously related to frequencies of the electromagnetic radiation. The energy at 300 MHz is more readily absorbed by the rats than at 40.68 MHz. The temperature changes of the rat's testes are most sensitive as compared with other parts of the rat's body. The results also showed temperature changes at the rat's anus are similar to those at body surface. The energy absorbed by the adult white rats exposed to radiant energies at 40.68 MHz and 300 MHz at the same time has more evident calorific effect than that at single frequency. Author (Hemer)

A95-95628
CHANGES IN ECG IN GROUND SQUIRRELS UNDER SEVERAL SPECIAL CONDITIONS
BAOLAN ZHANG Institute of Space Medico, Beijing, China, JINGXUE ZHANG, and QING WANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 60-62 In CHINESE (HTN-95-93127) Copyright

Experimental studies were carried out in adult ground squirrels under special conditions such as hypergravity, hypoxia and high temperature. Significant changes of ECG in the animals were observed, for example, passive ectopic rhythms, conduction and ST-T abnormalities. All these changes recovered to normal when the specific factor was removed. It is suggested that these changes are functional rather than pathological. Author (Hemer)

N95-30452 Texas Univ., Austin, TX. Dept. of Chemical Engineering.
BIOSENSORS BASED ON CROSS-LINKING OF *BIOTINYLATED GLUCOSE OXIDASE BY AVIDIN* Technical Report, 1 Jan. 1994 - 25 Jan. 1995
MARK S. VREEKE and PATRICK ROCCA (Institut National des Sciences Appliquees de Rouen, Mont Saint Aignan, France.) 19 Jan. 1995 20 p Limited Reproducibility: More than 20% of this document may be affected by poor print
(AD-A290439; TR-014-1995) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Avidin, having four biotin binding units, cross-links and immobilizes glucose oxidase (GOX) labeled with multiple biotins (B-GOX) when solutions of B-GOX and avidin are mixed on an electrode. The H2O2 flux generated in the B-GOX catalyzed oxidation of glucose by dissolved O2 is measured as an electroreduction current at a horseradish peroxidase (HRP) redox conducting hydrogel electrode poised at +100 mV (Ag/AgCl). The sensitivity of the resulting glucose sensor is 0.14A/sq cm/M with a linear range up to 2mM glucose. DTIC

N95-30512 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Section for Extreme Work Environment.
EFFECTS OF AIR BUBBLES ON RABBIT BLOOD BRAIN BARRIER
G. BOLSTAD, A. HJELDE, and A. O. BRUBAKK 1993 4 p
(PB95-195293) Avail: Issuing Activity (National Technical Information Service (NTIS))

In the present investigation three groups of six animals were infused with an isoosmotic solution of NaCl w/Macrodex and 1 percent Tween. The solution was saturated with air bubbles. Infusion of degassed NaCl solution alone affected white, but not grey matter of both hemispheres. This indicates that the infusion of NaCl, as such, at least partly may explain the formation of edema, in white matter, while this does not seem to be the case in grey matter. It is thus suggested that factors connected to infusion procedures may affect the Blood Brain Barrier (BBB) of rabbits. NTIS

N95-30515 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Section for Extreme Work Environment.
ARTERIAL GAS BUBBLES AFTER DECOMPRESSION IN PIGS WITH PATENT FORAMEN OVALE
A. VIK, B. M. JENSSEN, and A. O. BRUBAKK 1993 13 p Prepared in cooperation with Trondheim Univ., Norway
(PB95-195319) Avail: Issuing Activity (National Technical Information Service (NTIS))

With patent foramen ovale (PFO), thought to be a risk factor for some forms of decompression sickness (DCS), venous bubbles may pass through the patent opening to become arterial bubbles. We exposed 14 anesthetized, spontaneously breathing pigs to air at 5 bar (500 kPa, absolute pressure) for 30 min and then rapidly decompressed at 2 bar/min to 1 bar. We measured intravascular pressures, blood gases, and with transesophageal echocardiology, bubbles in the pulmonary artery and ascending aorta. Autopsy showed that six of the pigs had a PFO. Arterial bubbles occurred more frequently in the PFO group (in six out of six) than in the non-PFO group (in two out of eight, P less than 0.01). When arterial bubbles were detected, the venous bubble count and the pulmonary artery pressure tended to be lower in pigs with PFO than in pigs without a PFO. We conclude that a PFO increases the risk of arterial bubbles after decompression. NTIS

N95-30665 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Section for Extreme Work Environment.
EFFECT OF OXYGEN AND DECOMPRESSION BUBBLES ON INERT GAS WASHOUT
V. FLOOK, A. O. BRUBAKK, O. EFTEDAL, I. M. HOLMEN, and A. L. USTAD 13 Sep. 1994 109 p
(PB95-196556; STF23-A94031) Avail: Issuing Activity (National Technical Information Service (NTIS))

This report describes experiments designed to answer two questions: How does the use of increased oxygen in the breathing gas affect inert gas washout and How does the presence of decompression bubbles affect the washout of inert gas. The experiments were carried out on pigs, were designed in such a way that the *influence of oxygen was studied separately from the influence of* decompression bubbles, and involved direct measurement of blood nitrogen concentrations. The conclusions are: Increased partial pressure of oxygen slows down the rate of nitrogen washout to a degree which relates to the level of inspired oxygen; The presence of decompression bubbles slows the removal of inert gas from the body and this slowing relates to the number of mixed venous nitrogen concentration; The pressure of large numbers of decompression bubbles causes further uptake of nitrogen following return to normobaric conditions. NTIS

N95-31144# Illinois Univ., Urbana, IL. Dept. of Cell and Structural Biology.
AASERT-92 AUGMENTATION OF RESEARCH TRAINING IN CHRONOBIOLOGY: REGULATION OF THE MAMMALIAN CIRCADIAN CLOCK BY NEUROTRANSMITTERS Annual Report, 1 Jun. 1993 - 31 May 1994
MARTHA GILLETTE 31 May 1994 2 p
(Contract(s)/Grant(s): F49620-93-1-0413)
(AD-A288243; AFOSR-94-0681TR) Avail: CASI HC A01/MF A01

Our research program aims to understand the mechanisms by which major neurotransmitter pathways regulate the biological clock in the suprachiasmatic nucleus (SCN) of the mammalian brain. Our model species is the rat. The specific progress made by each of the three students supported by the AASERT award in FY1 is summarized below. Each of these students has maintained satisfactory grades and progress toward their degree requirements during the funding period. DTIC

N95-32040# Department of Energy, Washington, DC. Medical Applications and Biophysical Research Div.
SUMMARIES OF FISCAL YEAR 1994 PROJECTS IN MEDICAL APPLICATIONS AND BIOPHYSICAL RESEARCH
Apr. 1995 123 p
(DE95-010405; DOE/ER-0645) Avail: CASI HC A06/MF A02

This report provides information on the research supported in Fiscal Year 1994 by the Medical Applications and Biophysical Research Division of the Office of Health and Environmental Research. A brief statement of the scope of the following areas is presented: dosimetry; measurement science; radiological and chemical physics; structural biology; human genome; and medical applications. Summaries of the research projects in these categories are presented. DOE

N95-32358# Lawrence Livermore National Lab., Livermore, CA.
IMPLEMENTATION AND PERFORMANCE OF THE PSEUDOKNOT PROBLEM IN SISAL
J. FEO and M. IVORY Dec. 1994 15 p Presented at the High Performance Functional Computing, Denver, CO, 9-11 Apr. 1995
(Contract(s)/Grant(s): W-7405-ENG-48)
(DE95-009573; UCRL-JC-119529; CONF-9504126-1) Avail: CASI HC A03/MF A01

The Pseudoknot Problem is an application from molecular

biology that computes all possible three-dimensional structures of one section of a nucleic acid molecule. The problem spans two important application domains: it includes a deterministic, backtracking search algorithm and floating-point intensive computations. Recently, the application has been used to compare and to contrast functional languages. In this paper, we describe a sequential and parallel implementation of the problem in Sisal. We present a method for writing recursive, floating-point intensive applications in Sisal that preserves performance and parallelism. We discuss compiler optimizations, runtime execution, and performance on several multiprocessor systems. DOE

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AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and effects of weightlessness on man and animals.

A95-93778* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PROTEIN REQUIREMENTS FOR LONG TERM MISSIONS
T. P. STEIN University of Medicine and Dentistry of New Jersey, Stratford, New Jersey, U Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)157-(11)166
(Contract(s)/Grant(s): NAS9-17276)
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A key component of the diet for a space mission is protein. This first part of this paper reviews the reasons for emphasizing protein nurtition and then discusses what the requirements are likely to be. The second part discusses potential advantages of modifying these requirements and describes potential potential approaches to effecting these modifications based on well established ground based models. Author (revised by Hemer)

A95-93781
RECYCLING OF TRACE ELEMENTS REQUIRED FOR HUMANS IN CELSS
A. ASHIDA Space Systems Division, Chiyoda-ku, Tokyo, Japan Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)177-(11)187
Copyright

Recycling of complete nourishment necessary for humans should be provided in Controlled Ecological Life Support Systems (CELSS). Essential elements necessary for human support are categorized as major elements, semi-major elements and trace elements. Recently, trace elements have been identified in considerations of local diseases, food additive problems, pollution problems and adult diseases, consisting of Fe, Zn, Cu, Se, Co, F, Si, Mn, Cr, I, As, Mo, Ni, V, Sn, Li, Br, Cd, Pb, B. A review of the biogeochemical history of the earth's biosphere and the physiological nature of humans and plants explains some of the requirements. A possible route for intake of trace elements is considered in that trace elements are dissolved in some chemical form in water, absorbed by plants through their roots and then transferred to humans as foods. There may be a possibility that living things absorb some trace elements from the atmosphere. Management and recycling of trace elements in CELSS is discussed.
Author (revised by Hemer)

A95-93843
VALIDITY OF THE CONCEPT OF ABSORBED DOSE AS A PHYSICAL QUANTITY
JUNICHIRO TADA University of Tsukuba, Tsukuba, Japan and KAZUAKI KATOH National Laboratory for High Energy Physics, Tsukuba, Japan Physical Society of Japan, Journal (ISSN 0031-9015) vol. 64, no. 2 February 1995 p. 667-673
(HTN-95-B0593) Copyright

The concept of the 'absorbed dose' of ionizing radiation is scrutinized from physical point of view. It is shown that the concept and definition of the quantity in the ICRU system is disqualified as a physical quantity and the absorbed dose can not always be a 'measure of cause' in describing causality relation between radiation and effects on matter. The current absorbed dose depends even on the energy that have already been brought out from matter, contrary to the intention of introducing the quantity. Trials to remove these difficulties are made. However, it is also shown there still exists an essential problem that cannot be solved by improving the formulation. Author (revised by Hemer)

A95-94245
TREATMENT OF MURINE LUPUS WITH CTLA4LG
BARBARA K. FINCK Univ of California and Veterans Administration Medical Cent, San Francisco, CA, United States, PETER S. LINSLEY, and DAVID WOFSY Science (ISSN 0036-8075) vol. 265, no. 5176 August 26 1994 p. 1225-1227 refs
(BTN-95-EIX95302460580) Copyright

The interaction of B7-related molecules on antigen-presenting cells with CD28 or CTLA-4 antigens on T cells provides a second signal for T cell activation. Selective inhibition of the B7-CD28 or B7-CTLA-4 interactions produces antigen-specific T cell unresponsiveness in vitro and suppresses immune function in vivo. To determine whether selective inhibition of the B7-CD28 or B7-CTLA-4 interactions could suppress spontaneous autoimmune disease, a B7-binding protein was generated by genetic fusion of the extracellular domain of murine CTLA-4 to the Fc portion of a mouse immunoglobulin G2a monoclonal antibody (muCTLA4Ig). In lupus-prone NZB/NZW filial generation (F(sub 1)) mice, treatment with muCTLA4Ig blocked autoantibody production and prolonged life, even when treatment was delayed until the most advanced stage of clinical illness. These findings suggest a possible role for human CTLA4Ig in the treatment of autoimmune diseases in humans. Author (EI)

A95-94875
EFFECT OF PHASE ENCODING STEPS ON 1D CHEMICAL SHIFT IMAGING OF LACTATE DURING BRAIN ACTIVATION
M. SINGH Univ of Southern California, Los Angeles, CA, United States, D. KHOSLA, H. KIM, and T. KIM IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1656-1657 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424677) Copyright

Lactate is a unique indicator of brain activation and is detectable in vivo by proton magnetic resonance spectroscopy. Previous brain activation studies have been confined to single-voxel localization of lactate. To extend this work to 1D chemical shift imaging, computer simulation and test-object studies were conducted to examine tradeoffs among the number of phase encoding steps, signal-to-noise ratio (snr) and resolution. An iterative algorithm was developed to reduce truncation artifacts arising from a limited number of phase encoding steps. The results indicate that the resolution and snr attained with 8 phase encoding steps and 16 averages per step after applying the truncation reduction algorithm are approximately equal to those attained with 32 encoding steps and 4 averages per step. Thus, 32 steps would be preferred since contamination is minimized with increasing steps. Author (EI)

A95-94876
FUNCTIONAL MRI AT 1.5T
M. SINGH Univ of Southern California, Los Angeles, CA, United States, H. KIM, T. KIM, and D. KHOSLA IEEE Transactions on Nuclear Science (ISSN 0018-9499) vol. 41, no. 4, pt. 1 August 1994 p. 1649-1659 Proceedings of the 1993 Nuclear Science Symposium and Medical Imaging Conference (NSS-MIC'93). Part 1 (of 2), San

Francisco, CA, USA, Oct 30-Nov 6 199 refs
(BTN-95-EIX95332424676) Copyright

Human studies were conducted to determine the feasibility of functional MRI during auditory stimulation using conventional hardware (i.e., without echo-planar imaging) in a Philips 1.5T Gyroscan system. A gradient-echo pulse sequence was optimized to minimize the effect of gradient sound. Simple tonal stimulation and linguistic stimuli designed to activate regions responsible for comprehension were investigated. Also, functional images in response to visual and somatosensory stimulation were generated, albeit with a different gradient-echo sequence to optimize contrast and temporal resolution. A registration technique was developed to reduce head motion artifacts. Cerebrospinal fluid pulsation artifacts however, were not removable even with flow compensating gradient pulses. A phase-shift imaging technique was investigated which has the potential to separate the relatively large blood vessels from the microvasculature. Results of functional imaging indicate a 2-9% increase in signal intensity localized to the corresponding auditory, visual or somatosensory brain regions during stimulation. Author (EI)

A95-95132
LOW-LEVEL ALCOHOL EFFECTS ON PILOT READBACK PERFORMANCE: AN EXPLORATORY STUDY

O. VERONIKA PRINZO FAA, CAMI, Oklahoma, OK, US and THOMAS BRITTON FAA, CAMI, Oklahoma, OK, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 624-628
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The primary objective of this exploratory study was to evaluate a methodology for studying air traffic control (ATC) pilot communications; it was included as an ancillary part of a larger experiment that was designed to determine some effects on tracking performance of low blood alcohol levels. The results of this exploratory study suggested that initial readbacks are less accurate and dysfluencies more common than anticipated in the absence of alcohol. Some minimal effects of alcohol on the accuracy of pilot readbacks of ATC messages were indicated. However, use of BALs this low may not yield consistent results for memory of ATC message content versus delivery technique measures.
Author (revised by Hemer)

A95-95135
ACTIGRAPHY AND LOGBOOKS DURING LONG HAUL FLIGHTS: A FEASIBILITY STUDY

PIERRE J. L. VALK Netherlands Aerospace Medical Center, Soesterberg, Netherlands, RIES M. SIMONS Netherlands Aerospace Medical Center, Soesterberg, Netherlands, HANS J. D. DE REE KLM Royal Dutch Airlines, Schiphol, Netherlands, and BRINIO O. A. VELDHUI VAN ZANTEN KLM Royal Dutch Airlines, Schiphol, Netherlands *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 645-649
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Dutch aircrew operating on non-stop long-haul flights have a mandatory onboard rest period in a sleep bunk. The Netherlands Aerospace Medical Centre. A study has been conducted to determine feasibility of design and reliability of methods to be used in the assessment of the quantity and quality of home, layover, and onboard sleep of aircrew. 10 cockpit and 10 cabin crewmembers were studied during two trips, on which they accomplished their normal operational tasks. Subjects completed daily logs from the day prior to the trip, during the trip, and up to 2 days after the trip. The logbook included ratings of sleep quality (GSQS) and sleepiness (SSS), and items related to environmental and operational aspects. In addition, subjects wore an activity monitor throughout the trip to determine rest-activity patterns. Activity monitor data on the time spent in bed or in the bunk (home, onboard, layover rest) show significant corellations with subjective reports. It is concluded that actigraphy in combination with the use of logbooks is a useful method to record rest-activity patterns at home, onboard, and during layovers. Author (revised by Hemer)

A95-95136
ILLNESS, DRUGS, FATIGUE AND STRESS IN THE COCKPIT REPORTED BY PILOTS

RUDOLF G. MORTIMER Univ. of Illinois, Champaign, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 650-654
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The objectives of the study were to obtain estimates of the incidence of illnesses, use of drugs, fatigue and stress experienced by pilots while flying in a 90 day period. Pilots reported a variety of illnesses, most commonly headaches, earaches, motion sickness, anxiety, depression, join pains and muscle cramps, and less often chest pain, stomach ache, general physical weakness, visual impairments, colds and sinusitis, back pain and altered circadian rhythm. Fatigue was reported by 20%. About 26% reported some effects of the conditions on their performance, such as reduced alertness and peak performance. Unusual stress was reported by 28% due to home, work or social factors, 13% due to the condition or functioning of their aircraft, 28% due to flight conditions and 12% due to air traffic control. About 15% had taken prescription medicines, 37% non-prescription medicines, none reported use of narcotics or stimulants, but 29% had been drinking within 24 hours of a flight. A revision to FAR part 91.17 ('Alcohol or drugs') is recommended. Author (Hemer)

A95-95137
INITIAL DEVELOPMENT AND VALIDATION OF A MULTI-MODAL MODEL FOR UNDERSTANDING AND TREATING AIRSICKNESS

R. JEFFREY JACKSON U.S. Air Force Academy, US and GREGG F. TANOFF U.S. Air Force Academy, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 655-658
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The assessment and treatment of airsickness has not been guided by a comprehensive theoretical rationale. Until recently, airsickness has been approached as a one or two factor phenomenon in which a neural mismatch or some combination of cognitive and physical factors produced airsickness symptoms. A new multi—modal model posits that airsickness is a result of excesses or deficits in seven different domains. Consequently, this model presents greater specificity for understanding and treating such motion discomfort. Furthermore, not only has this model been developed on a rational basis, but initial validation data has been collected to examine its theoretical structure. This is the first effort to empirically test any theoretically derived model of airsickness.
Author (Hemer)

A95-95138
RECOGNIZING SUBTLE PHYSIOLOGICAL CUES: TRAINING TO PREVENT PILOT INCAPACITATION

DAVID B. BLUMKIN Univ. of North Dakota, ND, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 659-663
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The human is a complex system capable of detecting changes in the environment, and reacting to these changes in order to maintain stability with the environment. This state of stability with the environment, homeostasis, is necessary for the human system to operate at or near peak efficiency. The purpose of this paper is to emphasize the need for flight crews to be able to recognize subtle physiological cues that alert them to an imbalance in homeostasis and alert them to take proper corrective action. A failure to recognize these cues can lead to subtle, partial, or total incapacitation resulting in loss of aircraft control. Author (Hemer)

A95-95139
ANALYSIS OF USAF HYPOXIA INCIDENTS JANUARY 1976 THROUGH MARCH 1990
RICHARD T. ISLAND Univ. of North Dakota, ND, US and EARL V. FRALEY Univ. of North Dakota, ND, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 664-668

656 inflight incidents of hypoxia were reported to the USAF Safety Center between January 1976 and March 1990. These cases were analyzed to determine the effectiveness of high altitude physiological chamber training. Of the 606 cases involving chamber trained aircrew, only 3.8% experienced an in-flight loss of consciousness (LOC), while the untrained group of 50 had a LOC rate of 94%. As expected, the LOC rate for both groups increased as the altitude exposure increased. The LOC rate for the untrained group was 85% and higher at altitudes above 25,000. The National Transportation Safety Board (NTSB) mishap statistics show that hypoxia as a cause factor to be present in 40 aircraft mishaps accounting for 67 fatalities between 1965 and 1990, while during the same time, the USAF experienced only one fatality and aircraft loss. While making a direct comparison would require analysis of data beyond the scope of this paper, the numbers evaluated to indicate a significant value to altitude chamber training. Author (revised by Herner)

A95-95140
HIGH-ALTITUDE PHYSIOLOGY TRAINING
JOSEPH L. VOGEL Ohio State Univ., OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 673-676

The paper outlines current training regulations for pilots flying at high altitudes. It recommends that the basic core curriculum for every pilot trainee should be the same. This should include academic and physiological training. By instituting adequate training programs, and by anticipating those training needs, physiologically related accidents can be eliminated before they happen. Author (revised by Herner)

A95-95162
EYESTRAIN IN VIRTUAL ENVIRONMENTS
KEVIN S. BERBAUM Univ. of Iowa, IA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 791-794

Flight simulators are examples of virtual reality systems that are known to produce symptoms similar to those of motion sickness. A key difference is that simulators produce more commonly associated with eyestrain. In a large study of simulator sickness in U.S. Navy flight simulators, involving 10 different simulators and about 1200 simulated flights, it was noted that symptoms associated with eyestrain, including eyestrain, headache, difficulty focusing, blurred vision were the most commonly reported type of symptoms. Simulators that cause the highest levels of eyestrain were helicopter rather than fixed wing simulations, had multiple wide field of view CRT displays rather than dome-screen projection displays, and had motion bases. Author (revised by Herner)

A95-95163
SIMULATOR SICKNESS IMPLICATIONS FOR ADVANCED TRAINING TECHNOLOGIES
SHERRIE ANN JONES Naval Training Systems Center, Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 795-798

Advances in aviation training system technologies have improved training effectiveness and user acceptance. However, increases sophistication of visual and motion systems has produced a constellation of motion sickness symptomatology in simulator users, known as simulator sickness. An extensive knowledge base from the behavioral sciences exists which indicates a strong relationship between the illusory perception of self-motion (vection) and motion sickness symptomatoly. As simulation fidelity becomes increasingly convincing (i.e., vection-inducing), even slight deviation from normal visual, vestibular and proprioceptive correspondence is likely to induce sickness. This paper will discuss the simulator sickness issues associated with industrial advances in simulation technologies. Author (Herner)

A95-95164
DISORIENTATION AND POSTURAL DISEQUILIBRIUM FROM SIMULATED FLIGHT
ROBERT S. KENNEDY Essex Corp., Orlando, FL, US, KEVIN S. BERBAUM Univ. of Iowa, Iowa City, IA, US, MICHAEL G. LILIENTHAL Defense Modeling and Simulation Office, Alexandria, VA, US, and MARTIN G. SMITH Essex Corp., Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 799-804

Simulator sickness, a form of motion sickness, has been shown to occur in a large number of Navy, Army and Coast Guard simulators. Not all simulators occasion discomfort and different simulators present different incidences of sickness as well as different clusters of symptoms. Recently we conducted a factor analysis which organized symptoms into three empirically distinct clusters (Nausea, Disorientation, and Visuomotor) which correspond to theoretically meaningful neural centers (e.g. vagal, vestibular, and oculomotor). The purpose of this study was to compare the objective signs (ataxia) and these symptom profiles in pilots after simulator exposure. Data from two Navy simulators were analyzed. Significant correlations were found between scores on postural stability tests and the simulator sickness questionnaire (SSQ) Disorientation subscale scores, but correlations between scores on postural stability tests and the SSQ Nausea and Visuomotor subscale scores were much weaker. These results provide evidence for the validity of the Disorientation subscale of the SSQ and lend support to the intuitice prediction that disequilibrium is more related to disorientation symptoms than to nausea or oculomotor symptom clusters. Author (revised by Herner)

A95-95184
AN ANALYSIS OF PHYSIOLOGICAL METRICS IN THE STUDY OF PILOT SITUATIONAL AWARENESS
MICHAEL D. STRATTON Armstrong Lab. at Wright-Patterson AFB, OH, US, GLENN F. WILSON Armstrong Lab. at Wright-Patterson AFB, OH, US, and MARK S. CRABTREE Logicon Technical Services, Inc., Dayton, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 901-905

Situational awareness (SA) in the cockpit is gaining recognition as a decisive factor in aircraft confrontations. Physiological measures demonstrated sensitivity in relationship to the cognitive workload associated with flight task. Workload, or an individual's capacity to do work, should not be confused with SA. However, if SA is in part a military operator's knowledge of the immediate tactical situation, cognitive workload may play an indirect role in an individual's ability to establish SA, and could offer clues to an individual's ability to establish SA in the cockpit. The purpose of this study was to determine if workload sensitive physiological measures can be employed as an indirect measure of SA. Author (revised by Herner)

A95-95616
CHANGES OF SOME HORMONES AND INORGANIC SALTS IN EVOKED MOTION SICKNESS
JINGSHEN PEI Institute of Space Medico, Beijing, China, ZHENXIU LIU, TANGBIN YANG, BELUN TONG, YUHUA YANG, and WENYAN

JIN Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 7-11 In CHINESE
(HTN-95-93115) Copyright

Changes of seven different hormones: antidiuretic hormone (AVP), vasoactive intestinal peptide (VIP), cortisol (CORT), aldosterone (ALDO), epinephrine (E), norepinephrine (NE), thyroxine T4 and five inorganic salt (K, Na, Ca, P, Mg) in urine of 10 volunteer subjects were observed before and after exposures to parallel swinging and the vertical optokinetic stimulus on a large screen. The results showed that different types of stimulus (parallel swinging and vertial optokinetic stimulation) had different effects in inducing motion sickness (MS). The severity of MS symptoms elicited by parallel swinging were significantly higher than those elicited by the vertical optokinetic stimulation. Eight of the ten subjects under parallel swinging reached an M(sub III) endpoint of MS, while seven subjects following vertical optokinetic stimulation presented (M(sub I)) MS symptoms - slight malais. AVP and CORT were significantly increased before and after parallel swinging. After parallel swing stimulation, the scores of MS symptoms correlated with relative variation of urinary AVP. ALDO and VIP were markedly increased after vertical optokinetic stimulation. No significant changes of T4, E, NE, K, Na, Ca, P, Mg were found during exposures to both vertical optokinetic stimulation and parallel swinging. The causes of changes in AVP were discussed. It suggested that the detection of endocrine responsiveness in motion sickness might be of value for prediction of motion sickness and selection of astronauts. Author (Hemer)

A95-95619
ALGORITHM FOR REAL-TIME DETECTION OF QRS COMPLEX IN ECG SIGNAL
BOLIANG WANG National University of Defence Technology, Changsha, China, XISHUN LIU, and XIAOLING HUANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 23-26 In CHINESE
(HTN-95-93118) Copyright

A real-time detection algorithm for QRS complex was recommended. ECG signal was filtered by bandpass filter, and then moving window integral was made. Several features (such as slope and amplitude) were extracted. Adaptive amplitude thresholds were employed to make final determination whether the detected event is a QRS complex. This algorithm has been used in a microcomputer-based medical instrumentation - Intelligent Multichannel Analyzer (model GKD-450A), to make real-time measurement and to display patient's heart rate. Author (Hemer)

A95-95629
A STUDY OF ZINC COPPER AND MANGANESE METABOLISM DURING MILITARY EXERCISES IN HIGH TEMPERATURE ENVIRONMENT
RENZHI QIU The First Military Medical University, Guangzhou, China and WEIREN WAN The First Military Medical University, Guangzhou, China Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 63-66 In CHINESE
(HTN-95-93128) Copyright

Twenty male soldiers from an overall training troop participated 5 km cross-country running once daily for 10-12 days within 2w. Comparison between results of standard test before and after training period indicates that heat acclimatization improves obviously. The sweat volume and sweat Zn, Cu and Mn concentration decreased. The stool Mn and Cu, and Urine Mn decreased slightly. The stool Zn, and urine Zn and Cu increased greatly. The serum Zn, Cu and Mn decreased, while the serum Zn and Mn decreased less and Cu elevated after ration load (standard test). The serum Zn and Cu negative balance was alleviated. However, Mn positive balance contradicted with the low level of serum Mn. The great loss of sweat is the main factor causing Zn and Cu negative balance during exercises in heat. So the intake of Zn, Cu and Mn should be increased to meet the needs of the organism. Author (Hemer)

A95-95630
HEAD COOLING IN HYPERTHERMIA
CHENG PANG Institute of Space Medical-Engineering, Beijing, China and DINGLIANG GU Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 67-70 In CHINESE
(HTN-95-93129) Copyright

Hyperthermia can cause low working efficiency, and personal thermoconditioning equipment may be used for the relief of hyperthermia. The head region is preferred for local cooling because of its high cooling efficiency but its importance has not yet been recognized. This paper provided a series of experimental evidence for the systematic demonstration of head cooling efficiency as well as its effectiveness, which are especially important in aviation activities. Several medical-engineering problems are discussed in order to provide some references for equipment design.
Author (Hemer)

N95-30494 Direction des Recherches, Etudes et Techniques, Paris (France).
PHYSIOLOGY AND PHYSIOPATHOLOGY OF *EQUILIBRATION Final Report* [PHYSIOLOGIE ET PHYSIOPATHOLOGIE DE L'EQUILIBRATION]
Feb. 1994 80 p In FRENCH
(PB95-208328) Avail: Issuing Activity (National Technical Information Service (NTIS))

The study analyzes the transduction, transmission, and modulation of the vestibular sensorial message. It focuses on the role of calcium in the acquisition of the vestibular information and its control, and on the ion exchanges involved in these mechanisms.
NTIS

N95-30511 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Section for Extreme Work Environment.
DECOMPRESSION ILLNESS, OBSERVABLE BUBBLES. (SESSION K)
O. EFTEDAL, S. KOTENG, and A. O. BRUBAKK 1993 4 p Prepared in cooperation with Trondheim Univ., Norway
(PB95-195285) Avail: Issuing Activity (National Technical Information Service (NTIS))

A long period of training is required for Doppler raters to reach a standard where they can work independently grading Doppler recordings for intravascular gas bubbles. The aim of this study was to evaluate Transesophageal Echocardiography (TEE) imaging and a grading system with 6 levels as a method for quantifying bubbles. A video tape with 20 1-minute TEE recordings was shown individually to 20 persons. None of the raters had any previous experience with bubble grading. A total of 400 gradings were performed. 293 gradings were consistent with what had been protocolled, 100 differed by 1 grade, 6 differed by 2 grades and 1 differed by 3 grades. We conclude that TEE imaging is well suited for quantitative evaluation of intravascular gas bubbles, even by persons with little previous experience. The grading scale used in the experiments can probably be improved by altering the definitions of grade 1 and 2.
NTIS

N95-30513 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Section for Extreme Work Environment.
DETECTING INTRAVASCULAR GAS BUBBLES IN ULTRASONIC IMAGES
O. EFTEDAL and A. O. BRUBAKK Nov. 1993 9 p Prepared in cooperation with Trondheim Univ., Norway
(PB95-195301) Copyright Avail: Issuing Activity (National Technical Information Service (NTIS))

To study the effects of decompression on the human body, a reliable system for determining the presence and number of intravascular gas bubbles is required. Detection methods involving ultrasound enable portable, non-invasive systems that can be used in many different situations to be developed. A system capable of identifying single bubbles, even when the number of bubbles is high, would give a linear measure of the total number of intravascular gas bubbles. In scanned two-dimensional ultrasonic images, the grey scale value of each pixel is obtained through a logarithmic amplification of the amplitude of the reflected ultra-

sound from the corresponding sample volume. Gas bubbles appear as bright 'blobs' in the images. By digitizing the images, simple computer programs for automatic identification of such blobs are feasible. Systems for digitizing and transferring ultrasonic images to computers are commercially available. We present a computer program, EchoBubble, that performs automatic identification and quantification of intravascular gas bubbles in digitized images.
NTIS

N95-30563# Naval Health Research Center, San Diego, CA.
CONTROL OF SKIN BLOOD FLOW IN THE NEUTRAL ZONE OF HUMAN BODY TEMPERATURE REGULATION Final Report
MARGARET V. SAVAGE, GEORGE L. BRENGELMANN, DONALD E. ROBERTS, and ROBERT S. POZOS 4 Nov. 1994 37 p
(AD-A291499; NHRC-94-27) Avail: CASI HC A03/MF A01

In humans, matching of heat loss and heat production in the 'neutral' zone, defined operationally in terms of a range of skin temperatures (Tsk), is accomplished by regulation of skin blood flow (SkBF). In four men and four women, we investigated the control of SkBF in this range by setting Tsk at 33 and 35 C in a square wave pattern (15 min at each temperature) or a step pattern (60 min at 33 C separating short periods at 35 C) by means of water sprayed over the entire body except the head, neck, and one forearm. Forearm blood flow (FBF) followed the pattern of Tsk, both in the forearm in which Tsk followed that of the rest of the body and in the arm exposed to room air (average local Tsk 31.22 C). Esophageal temperature (Tes) rose after Tsk fell and vice versa. This inverse relationship is predicted by a simple one-compartment thermal model in which control of SkBF is simulated as a linear combination of skin and core temperature (Tc). Similar patterns of Tsk applied to only one arm had little influence on FBF. We conclude that the feedforward reflex influence of Tsk on SkBF overcompensates for the effect of Tsk on thermal balance in the neutral zone so that equilibrium Tc has an inverse relationship to Tsk. DTIC

N95-30846*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
ELECTROMYOSTIMULATION, CIRCUITS AND MONITORING
DONALD F. DOERR 1994 5 p
(NASA-TM-110741; NAS 1.15:110741) Avail: CASI HC A01/MF A01

One method to determine the benefit of electromyostimulation (EMS) requires an accurate strength assessment of the muscle of interest using a muscle force testing device. Several commercial devices are available. After a pre-EMS muscle assessment, a protocol with accurately controlled stimulation parameters must be applied and monitored. Both the actual current and the resultant muscle force must be measured throughout the study. At the conclusion of the study, a reassessment of the muscle strength must be gathered. In our laboratory, electromyostimulation is being studied as a possible countermeasure to the muscle atrophy (degeneration) experienced in space. This muscle loss not only weakens the astronaut, but adversely affects his/her readaptation to 1-g upon return from space. Muscle atrophy is expected to have a more significant effect in long term space flight as anticipated in our space station. Our studies have concentrated on stimulating the four major muscle groups in the leg. These muscles were stimulated sequentially to allow individual muscle force quantification above the knee and ankle. The leg must be restrained in an instrumented brace to allow this measurement and preclude muscle cramping.
Derived from text

N95-30870# Lovelace Scientific Resources, Inc., Albuquerque, NM. Inst. for Basic and Applied Medical Research.
CONFERENCE PERSPECTIVE.
NEUROIMMUNOMODULATION: STRESS AND IMMUNE FUNCTION
MICHAEL C. POWANDA (M/P Biomedical Consultants, Mill Valley, CA.) and MATTHEW J. KLUGER 9 Feb. 1995 11 p Conference held in Albuquerque, NM, 7-9 Oct. 1994
(Contract(s)/Grant(s): N00014-95-1-0124)
(AD-A291351) Avail: CASI HC A03/MF A01

The bidirectional communication and interaction between the brain and the immune system is one of the most exciting areas of biomedical research. Although many symposia contain sessions relating to the above topic (e.g. Experimental Biology 1994, Neurosciences), there are few meeting devoted exclusively to this topic. Most of these have been in foreign countries, which limits the participation of American scientists. Some 25 distinguished scientists lectured in the workshop/symposium, and another 50-60 scientists were participants. The symposium was held in a state-of-the-art conference facility, and there was ample opportunities for one-on-one discussion of science. A more detailed description of the symposium is provided. DTIC

N95-30924# Georgia Univ., Athens, GA.
MEMBRANE TRANSPORT: A CELLULAR PROBE OF HEAT STROKE Midterm Report
JOHN S. WILLIS 2 Feb. 1995 37 p
(Contract(s)/Grant(s): DAMD17-93-J-3031)
(AD-A293327; REPT-10-21-RR194-207) Avail: CASI HC A03/MF A01

Red blood cells of guinea pig were used to explore the effects of temperatures above 37 C on membrane permeability to Na+ and K+ as part of an effort to evaluate the Energy Depletion Hypothesis of heat stroke. Cell Na+ and K+ does not change at 41 C and 45 C for up to 2 hours of incubation in simple saline medium. Na-K pump activity measured as ouabain-sensitive K+ influx increases with warming, as do Na+ influx and K influx. The rise in the pump activity matches the rise in Na+ influx quantitatively, accounting for the lack of change in Na+ cell. The rise in Na+ influx is in the face of a decrease in activity of Na-H exchange transport capacity. The rise in K+ influx consists largely of activation of a single, carrier-mediated path, K-C1 cotransport and corresponds to an apparent activation of this path in the reverse direction (K+ efflux), leading to dumping of K+ at elevated temperature. Na-K-C1, a third passive carrier pathway, shows a temperature optimum between 30 C and 37 C. A new hypothesis proposes that these diverse responses to temperature change contribute to the maintenance of ion balance. DTIC

N95-30981# Naval Surface Warfare Center, Silver Spring, MD.
ELECTROMAGNETIC FIELD EXPOSURE DOSIMETER Final Report, Sep. 1992 - May 1993
A. C. FEAGA, M. P. HILLIARD, and R. LINK 28 Jul. 1994 32 p
(AD-A293191; NSWCDD/TR-94/76) Avail: CASI HC A03/MF A01

The growing concern about adverse health effects caused by electromagnetic radiation prompted the ideas for this dosimeter. Data have been presented that link prolonged exposure to electromagnetic radiation from power lines to leukemia and some types of cancer. At present, though, there is a lack of recording instrumentation to measure the prolonged exposure of an individual; thus, it is not possible to correlate properly the amount of exposure or dose to health effects. With the recent advances in small, low-power devices, a small measuring device can be developed. Once this is built, a large data base can be obtained to help correlate electromagnetic field exposure to health conditions. The objective of this project is to develop an instrument which can measure electromagnetic fields over a prolonged period of time. The instrument would be small, say about the size of a radio Walkman, and would be worn throughout the day while taking data, as the individual goes about normal activities. A PC would be used to retrieve the data from the instrument at the end of the day. The dosimeter comprises a triaxial ferrite-loaded coil sensor, a set of amplifiers and filters, analog-to-digital converters, a microcontroller, and random access data memory. The signals from the sensor are filtered into three frequency ranges: one to measure 60-Hz exposure and two harmonics, another to measure high-energy pulsed energy, and a third frequency range to record the activity level of the individual. The signals from the filters are digitized and read into a microcontroller. The microcontroller performs a few calculations and controls the flow of the data to either

random access memory or to a computer. A computer is used to retrieve the data from the dosimeter, and can store and display the measured data. DTIC

N95-30998# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
EVALUATION OF CALIBRATION PARAMETERS AND PERFORMANCE OF THE VIDEO IMAGING TECHNIQUE OF ASSESSING EXPOSURE (VITAE SYSTEM) M.S. Thesis
KEITH M. GROTH Aug. 1994 128 p
(AD-A289023; AFIT/CI/CIA-94-130) Avail: CASI HC A07/MF A02

Assessing exposures to chemicals that can be absorbed through the skin presents the industrial hygienist with a perplexing and sometimes frustrating dilemma. The fact that three of the articles appearing in the February 1993 AIHA Journal addressed surface wipe sampling is a testament to an increasing concern over the impact of dermally absorbed chemicals. In addition to increased awareness of percutaneous absorption as a potentially major factor in total body burden, this concern probably is fueled by frequent reductions in the allowable levels of many airborne contaminants for the workplace. As allowable workplace levels drop, the percentage of total body burden that is a result of dermal absorption may increase. This is especially true if dermal exposures are not controlled as rigorously as inhalation exposures. In fact, in many instances where the chemical has a low vapor pressure and is not aerosolized, dermal absorption is the primary route of exposure. DTIC

N95-31373# Armstrong Lab., Brooks AFB, TX. Crew Systems Directorate.
FORWARD RAPID ROTATION SHIFTWORK IN USAF AIR TRAFFIC CONTROLLERS: SLEEP, ACTIVITY, FATIGUE AND MOOD ANALYSES Interim Technical Report, 10 Aug. - 3 Sep. 1992
THOMAS D. LUNA, JONATHAN FRENCH, JENNIFIER L. MITCHA, and KELLY J. NEVILLE 9 Dec. 1994 33 p
(Contract(s)/Grant(s): AF PROJ. 7930)
(AD-A293448; AL/CF-TR-1994-0156) Avail: CASI HC A03/MF A01

The purpose of this study was to evaluate the shift-specific sleep, general activity levels, mood and cognitive performance of air traffic controllers (ATC's) working a forward 2-2-2 rapid rotation shift schedule. ATC's recorded their sleep, oral temperature and subjective fatigue levels, took a computerized cognitive performance battery (N=13) and completed the Profile of Mood States questionnaire (POMS) (N=12). Actigraphs were used to objectively monitor general activity levels and score sleep and the restlessness of scored sleep (N=9). Analyses were made on the basis of duty shift, post-shift, day of shift, and duty location. There was significantly more actigraph scored sleep, subjectively reported sleep and subjectively measured fatigue and confusion for the ATC's while they were on duty on the night-shift. The night-shift was also associated with decreased vigor and general activity levels. Significantly more sleep was reported following the first day on each of the three shifts than following the second. Significantly more sleep was reported and scored by actigraph following the swing-shift than following the day-shift. A comparison group of non ATC day-workers reported more post-shift sleep than the ATC's. The radar approach ATC's reported greater confusion and less vigor than the tower ATC's. Insufficient trials were available for direct performance analysis. DTIC

N95-31446# Madigan Army Medical Center, Takoma, WA. Dept. of Clinical Investigation.
USE OF BODY SURFACE HEAT PATTERNS FOR PREDICTING AND EVALUATING ACUTE LOWER EXTREMITY PAIN AMONG SOLDIERS Final Report, 15 Dec. 1989 - 30 Sep. 1994
RICHARD A. SHERMAN 12 Dec. 1994 53 p
(Contract(s)/Grant(s): MIPR-90MM052D)
(AD-A292829) Avail: CASI HC A04/MF A01

This project determined (1) that neither thermographs or podoscopes can be used to predict which basic trainees are likely to develop significant lower limb pain during training, (2) that thermography is not clinically useful in tracking changes in training related lower limb pain, (3) that contact thermographs are not useful in the TMC environment due to their inaccuracy, that videothermographs are too cumbersome and expensive to use relative to the information provided in the TMC environment, but that infrared beam thermometers are valuable adjuncts to assessment and tracking, (4) that having trainees wear shock absorbing inserts throughout basic training does not reduce the incidence and severity of lower limb pain, and (5) that training related stress fractures probably do heal faster when exposed to pulsing electromagnetic fields. DTIC

N95-31552# Armstrong Lab., Brooks AFB, TX. Aerospace Medicine Directorate.
SIMULATION OF OCULOMOTOR POST-INHIBITORY REBOUND BURST FIRING USING A HODGKIN-HUXLEY MODEL OF A NEURON
JOHN D. ENDERLE and EDWARD J. ENGELKEN 13 Feb. 1995 7 p
(Contract(s)/Grant(s): AF PROJ. 7755)
(AD-A293821; AL/AO-PC-1995-0012) Avail: CASI HC A02/MF A01

A number of theories have been reported on post saccade phenomenon describing dynamic overshoot, glissadic overshoot and undershoot, and undershoot, all naturally and frequency occurring saccadic eye movements. Electrophysiological evidence for post-inhibitory rebound burst firing activity during saccadic eye movements is prevalent in the literature. However, the cause for the phenomenon is not known. Marked inhibition of neurons within the Paramedian Pontine Reticular Formation often results in post-inhibitory rebound burst firing activity at the beginning and end of a saccade. In this paper, post-inhibitory rebound burst firing activity after marked hyperpolarization is postulated to occur in the Paramedian Pontine Reticular Formation due to a low membrane threshold voltage. With this biophysical property, a single neuron is capable of firing at high rates automatically and without stimulation when released from inhibition. Simulations using the Hodgkin-Huxley model of a neuron demonstrate that a single neuron is capable of firing at high rates automatically without stimulation when released from inhibition. DTIC

N95-31570# Tel-Aviv Univ., Ramat-Aviv, Tel-Aviv (Israel).
LASER INDUCED VITREORETINAL SCARRING. EVALUATION OF CAUSATIVE FACTORS AND A THERAPEUTIC APPROACH Final Report, 1 Sep. 1991 - 30 Sep. 1994
NAVA NAVEH and NAPHTHALI SAVION 10 Mar. 1995 50 p
(Contract(s)/Grant(s): DAMD17-91-Z-1031)
(AD-A293742) Avail: CASI HC A03/MF A01

Eyes subjected to laser exposure develop an inflammatory reaction, leading to scarring and bleeding, ensuing in visual impairment. This study demonstrated two main findings. (1) The angiogenic (neovascularization) activity of vitreous from lasered eye in rats cornea: The DPI an NADPH inhibitor curtailed significantly angiogenesis, as well as the initial vascular response. (2) Vitreous of lasered eyes enhances cell proliferation of retinal pigment epithelium, vascular endothel: This unique finding explains the development of visual impairment weeks and months post laser of subjects unaware of being hit by laser. Therefore subjects exposed to laser should be screened regularly to find laser lesions and a therapeutic regimen of antioxidants and/or steroidal should be initiated. DTIC

N95-31714# National Aerospace Lab., Tokyo (Japan).
DYNAMICAL ANALYSIS OF THE CORIOLIS EFFECT WHICH CAUSES SPACE DISORIENTATION
TAKAO SUZUKI, JIRO KOO (Tokai Univ., Hiratsuka, Japan.), and MASAKI KUME (Mukaino-oka Technical High School, Japan.) Oct. 1994 10 p In JAPANESE
(ISSN 0389-4010)
(NAL-TR-1258) Avail: CASI HC A02/MF A01

The coriolis effect or illusion is a sensation of angular motion in response to an inclination of the head when the head is undergoing

a passive rotation. A dummy head including three gyros and three accelerometers was assembled, and was supported with a pivot and four springs to simulate human neck mechanisms. The dummy head was tilted on a rotating table and the data obtained by the inertial sensors were analyzed to explain the cause of the Coriolis effect responsible for the illusion. In conclusion, the force acting on the dummy head is proportional to the angular velocity of the rotating table as well as to the linear velocity of the tilting motion. The force is found to be well described mainly by the principle of the coriolis acceleration. Author

N95-32097# Lawrence Livermore National Lab., Livermore, CA.
AUTOMATED VOLUMETRIC GRID GENERATION FOR FINITE ELEMENT MODELING OF HUMAN HAND JOINTS
K. HOLLERBACH, K. UNDERHILL, and R. RAINSBERGER Feb. 1995 4 p Presented at the 1995 ASME Summer Bioengineering Conference, Beaver Creek, CO, 28 Jun. - 2 Jul. 1995
(Contract(s)/Grant(s): W-7405-ENG-48)
(DE95-009575; UCRL-JC-119773; CONF-9506173-1) Avail: CASI HC A01/MF A01

We are developing techniques for finite element analysis of human joints. These techniques need to provide high quality results rapidly in order to be useful to a physician. The research presented here increases model quality and decreases user input time by automating the volumetric mesh generation step. DOE

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BEHAVIORAL SCIENCES

Includes psychological factors; individual and group behavior; crew training and evaluation; and psychiatric research.

A95-95037
INTERNATIONAL SYMPOSIUM ON AVIATION PSYCHOLOGY, 7TH, COLUMBUS, OH, APRIL 26-29, 1993. VOLS. 1 & 2
RICHARD S. JENSEN, editor Ohio State Univ., Columbus, OH, US and DAVID NEUMEISTER, editor Ohio State Univ., Columbus, OH, US Columbus, OH Ohio State University April 1993 1083 p.
(HTN-95-52325) Copyright

The conference proceedings contains papers giving extensive coverage to the following topics: cockpit technology, flight deck information management, adaptive automation, air carrier operations, pilot judgement, new approaches to decision making on the flight deck, cognitive factors, perception, management and safety, air traffic control (ATC) human factors, pilot selection, crew resource management, aviation physiology, stress and fatigue, pilot training, flight simulation, simulator sickness, workload, situational awareness, performance assessment, flight safety, and pilot error. For individual titles, see A95-95038 through A95-95210. Hemer

A95-95041* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MANAGING SYSTEMS FAULTS ON THE COMMERCIAL FLIGHT DECK: ANALYSIS OF PILOTS' ORGANIZATION AND PRIORITIZATION OF FAULT MANAGEMENT INFORMATION
WILLIAM H. ROGERS Bolt, Beranek & Newman, Inc., Hampton, VA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 42-48
(Contract(s)/Grant(s): NAS1-18788)
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In rare instances, flight crews of commercial aircraft must manage complex systems faults in addition to all their normal flight tasks. Pilot errors in fault management have been attributed, at least in part, to an incomplete or inaccurate awareness of the fault situation. The current study is part of a program aimed at assuring that the types of information potentially available from an intelligent fault management aiding concept developed at NASA Langley called 'Faultfinde' (see Abbott, Schutte, Palmer, and Ricks, 1987) are an asset rather than a liability: additional information should improve pilot performance and aircraft safety, but it should not confuse, distract, overload, mislead, or generally exacerbate already difficult circumstances. Author (revised by Hemer)

A95-95046* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ATTENTIONAL LIMITATIONS WITH HEAD-UP DISPLAYS
ROBERT S. MCCANN Sterling Software, Palo Alto, CA, US, DAVID C. FOYLE NASA. Ames Research Center, Moffett Field, CA, US, and JAMES C. JOHNSTON NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 70-75
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Recent models of visual information processing suggest that visual attention can be focussed on either Head-Up Displays (HUD) or on the world beyond them, but not on both simultaneously. This hypothesis was tested in a part-task simulation in which subjects viewed a simulated approach to a runway with a HUD superimposed. An alphanumeric cue ('IFR' or 'VFR') appeared on either the HUD or the runway and was followed by two sets of three geometric forms; one set on the HUD and one set on the runway. Each set contained one potential target, either a stop sign or a diamond. If the cue spelled 'IFR', subjects made a speeded response based on the identity of the HUD target; if the cue spelled 'VFR', subjects made a speeded response based on the identity of the runway target. Regardless of cue location (HUD or Runway), responses were faster when the cue and the relevant target were part of the same perceptual group (i.e., both on the HUD or both on the runway) than when they were part of different perceptual groups. These results, as well as others, suggest that attentional constraints place severe limits on the ability of pilots to process HUD-referenced information and world-referenced information simultaneously. In addition, they provide direct evidence that transitioning from processing HUD information to processing world information requires an attention shift. Implications for HUD design are considered. Author (Hemer)

A95-95047
PERFORMANCE EFFECTS OF INSTRUMENT SYMBOLOGY DISPLAYED IN NIGHT VISION GOGGLES DURING SIMULATED CONTOUR FLIGHT
JOHN C. MOREY Dynamics Research Corp., Wilmington, MA, US, ROBERT SIMON Dynamics Research Corp., Wilmington, MA, US, and DENNIS K. LEEDOM U.S. Army Aviation Research and Development Activity, Ft. Rucker, AL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 76-79
(Contract(s)/Grant(s): MDA-903-92-D-0025)
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The Aviator Night Vision Imaging System (ANVIS) intensifies low-level visible and near-infrared light, enabling military helicopter pilots to fly with increased effectiveness at night. A technology improvement being planned is the integration of flight instrument symbology into the visual array of the ANVIS. This development is an application of head-up display (HUD) and helmet-mounted display (HMD) concepts that permit the pilot to observe flight information superimposed on the out-the-window (OTW) scene viewed through the ANVIS. The integrated ANVIS-HMD introduces the flight symbology into one of the pair of ANVIS intensifier tubes attached to the pilot's helmet. The present experiment examined the effect of dichoptic viewing of instrument symbology and the possible influence of cognitive capture. Rated pilots flew a demanding mission on a high-fidelity simulator. Introducing the HMD into the ANVIS had no appreciable positive or negative effects on the pilots. They did not show experience and sighting dominance effects. In addition, the data suggest the absence of cognitive capture on the superimposed symbology image.
Author (revised by Hemer)

A95-95054* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CATEGORIZATION AND PRIORITIZATION OF FLIGHT DECK INFORMATION
JON E. JONSSON McDonnell Douglas Aerospace-West, US and WENDELL R. RICKS NASA. Langley Research Center, Hampton, VA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 126-131
Copyright
The paper describes an experiment whose objectives were to: (1) make initial inferences about categories into which pilots place information; and (2) empirically determine how pilots mentally represent flight deck information, and how their cognitive processes of categorization and prioritization act upon those representations. Author (Herner)

A95-95055* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COGNITIVE REPRESENTATIONS OF FLIGHT-DECK INFORMATION ATTRIBUTES
WENDELL R. RICKS NASA. Langley Research Center, Hampton, VA, US, JON E. JONSSON McDonnel Douglas Aerospace-West, Long Beach, CA, US, and WILLIAM H. ROGERS Bolt Beranek and Newman, Cambridge, MA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 132-137
Copyright
The experiment described in this paper had two objectives. The first objective was to empirically identify how pilots organize flight-deck information attributes. Such an organization should provide a useful nomenclature for classifying Information Management (IM) issues and problems. The second objective of this study was to empirically assess pilots' estimate of the relative importance of each attribute on managing information. Results from addressing this latter objective were intended to suggest areas on which flight-deck researchers and designers will want to focus their attention.
Author (Herner)

A95-95065* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DISTRIBUTED PROBLEM SOLVING BY PILOTS AND DISPATCHERS
JUDITH ORASANU NASA. Ames Research Center, Moffett Field, CA, US, MIKE WICH NASA. Ames Research Center, Moffett Field, CA, US, UTE FISCHER NASA. Ames Research Center, Moffett Field, CA, US, KIM JOBE NASA. Ames Research Center, Moffett Field, CA, US, ELAINE MCCOY Univ. of Nebraska, NE, US, ROGER BEATTY Airline Dispatchers Federation, US, and PHIL SMITH Ohio State Univ., OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 192-197
Copyright
The study addressed the following question: Are flight planning problems solved differently by PILOTS and DISPATCHERS when they work alone versus when they work together? Aspect of their performance that were of interest include the following: Problem perception and definition; Problem solving strategies and information use; Options considered; Solution and rational; and errors.
Author (Herner)

A95-95067
COCKPIT CRISES AND DECISION MAKING: IMPLICATIONS FOR PILOT TRAINING
MAUREEN A. PETTITT California State Univ., Los Angeles, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 221-225
Copyright
In recent years many airlines have initiated training programs to encourage effective cockpit resources management (CRM). The purpose of the study was to examine pilots' perceptions about three constructs central to decision making in cockpit crisis situation — the perception of crisis, sense of urgency, and response rigidity. The research indicates that CRM training improves attitudes toward crew coordination and decision making. Author (revised by Herner)

A95-95068* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A TAXONOMY OF DECISION PROBLEMS ON THE FLIGHT DECK
JUDITH M. ORASANU NASA. Ames Research Center, Moffett Field, CA, US, UTE FISCHER NASA. Ames Research Center, Moffett Field, CA, US, and RICHARD J. TARREL NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 226-232
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Examining cases of real crews making decisions in full-mission simulators or through Aviation Safety Reporting System (ASRS) reports shows that there are many different types of decisions that crews must make. Features of the situation determine the type of decision that must be made. The paper identifies six types of decisions that require different types of cognitive work and are also subject to different types of error or failure. These different requirements, along with descriptions of effective crew strategies, can serve as a basis for developing training practices and for evaluating crews. Author (revised by Herner)

A95-95069
DETERMINING THE DECISION REQUIREMENTS OF COMPLEX FLIGHT CREW TASKS
MARVIN THORDSEN Klein Associates Inc., Fairborn, OH, US, LAURA MILITELLO Klein Associates Inc., Fairborn, OH, US, and GARY KLEIN Klein Associates Inc., Fairborn, OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 233-237
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The historical emphasis of training in the Air Force, and in the Department of Defense, has been on procedural skills. Our intent is to explore the utility of Cognitive Task Analysis (CTA) for identifying difficult decisions and judgments in order to help determine decision-centered training requirements. Specifically, we are interested in identifying the decision-centered training requirements for the teams involved in high-performance, multiship air-to-air engagements. We have organized this paper in four parts: (1) a brief review of CTA, (2) a description of a CTA application from a project we conducted with Armstrong Laboratory, Williams AFB, (3) a review of the decision-centered training requirements resulting from this CTA, and (4) a discussion of the implications of identifying decision-centered training requirements. Author (revised by Herner)

A95-95070* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFICIENT DECISION STRATEGIES ON THE FLIGHT DECK
UTE FISCHER NASA. Ames Research Center, Moffett Field, CA, US, JUDITH ORASANU NASA. Ames Research Center, Moffett Field, CA, US, and MIKE MONTALVO NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 238-243
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Both crew productivity and flight safety depend critically on efficient crew problem solving and decision making. But what constitutes efficient problem solving and decision making behavior? Previous work has focused on crew performance in the context of a specific problem type. The present study differs from these analyses in two respects. First, we describe how aircraft crews cope with

different types of problems. And second, we attempt to discern characteristics of optimal task management behavior. For this reason, we contrasted the behavior of more effective and less effective crews. Underlying this approach is the assumption that crews whom commit few operational errors also demonstrate most efficient problem solving and decision making behavior. Author (revised by Herner)

A95-95071* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TAKING RISKS AND TAKING ADVICE: THE ROLE OF EXPERIENCE IN AIRLINE PILOT DIVERSIONS
MARVIN S. COHEN Cognitive Technologies, Inc., Arlington, VA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 244-247
(Contract(s)/Grant(s): NAS2-13056)

The research asks how pilots make diversion decisions, what factors determine whether they are make well or poorly, and how they may be improved. The results support the view that experienced decision makers may solve problems in a way that is qualitatively different from the approaches of less experienced decision makers. The results also support a concept of expertise that goes beyond a stock of specialized recognitional templates, to include domain-specific methods for processing information. Such metacognitive skills evolve through long experience. They may enhance both the accuracy and the efficiency of decision processes. Author (revised by Herner)

A95-95072
AERONAUTICAL DECISION MAKING AND CONSISTENCY OF CREW BEHAVIORS: IMPLICATIONS FORTRAINING
CAROLYN PRINCE Naval Training Systems Center, US, CHARMINE HARTEL Univ. of Tulsa, OK, US, and EDUARDO SALAS Naval Training Systems Center, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 248-251

Aeronautical decision making (ADM) is a critical element in every flight. The research focused on the undergraduate aviator who has passed the primary portion of training, where cockpit decisions are first encountered without the constant oversight of an instructor. The purposes of this analysis were to explore and classify the decision making strategies employed by inexperienced crewmembers in immediate response to different types of problems and to determine if there were differences in the application of immediate strategies between those crews who performed better (according to their technical performances) and those who performed less well. A small group of instructor pilots were included for comparison. These questions were designed to help in addressing the most important objective, determining the implications for training. Author (revised by Herner)

A95-95073
EXPERTISE IN AERONAUTICAL DECISION MAKING: A COGNITIVE SKILL ANALYSIS
DAVID O'HARE Univ. of Otago, Dunedin, New Zealand and MARK WIGGINS Univ. of Otago, Dunedin, New Zealand *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 252-256

The purpose of the study was to compare the decision making of expert pilots with many thousands of hours of cross-country VFR experience, with that of experienced, but not expert pilots, and that of comparative beginners. The results showed that pilots who had logged a considerable number of cross-country hours made faster, more confident decisions based on a more rapid and efficient search of the available information. The experts' path through the information presented was faster, more goal-directed and less subject to working memory constraints. Author (revised by Herner)

A95-95074
ERROR IN TIME MANAGEMENT DURING FIGHTING MISSION
JEAN YVES GRAU CERMA, France *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 257-262

To improve flight safety, enhanced knowledge of time-related information processing mechanisms is required. Initial studies explored pilot activity in actual or simulated flights and developed a cognitive in actual or simulated flights and developed a cognitive model of fighter pilot reasonning (Amalberti and al., 1992). This dynamic model takes time factors in short and long term activity management into account. The purpose of this paper is to describe features of time assessment and time management in fighter pilot activity, and to specify time related mechanisms which may be involved in flight accidents. Author (Herner)

A95-95075
AN APPROACH TO MODELING PILOT MEMORY AND DEVELOPING A TAXONOMY OF MEMORY ERRORS
SUSAN J. MANGOLD Battelle, Columbus, OH, US and DONALD ELDREDGE Battelle, Columbus, OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 263-268

Incidents that involve the remembering and forgetting of critical flight information by pilots are often found in the Aviation Safety Reporting System (ASRS) database. Investigating such problems in greater detail requires the capability to easily access relevant incident reports. To this end, a preliminary taxonomy of memory-related key words was developed that could be incorporated into the existing ASRS key word set. This paper provides a brief review of the methodology used to develop a memory-related taxanomy, and describes some of the lessons learned during this process that should be considered if a more comprehensive human factors taxonomy is to be developed. Author (Herner)

A95-95076
TIME PRESSURE AS A CAUSAL FACTOR IN AVIATION SAFETY INCIDENTS: THE 'HURRY-UP' SYNDROME
JEANNE MCELHATTON Batelle, Mountain View, CA, US and CHARLES DREW Batelle, Mountain View, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 269-274

In this study, the Hurry Up Syndrome is defined as any situation where a pilot's human performance is degraded by a perceived or actual need to 'hurry,' or 'rush' tasks or duties for any reason. The overall objective of this research project was to identify those flight regimes and scenarios that led to time pressure (Hurry Up Syndrome) related pilot errors and deviations, to suggest methods by which pilots may recognize the symptoms and onset of the Hurry Up Syndrome, and to formulate intervention strategies in order to achieve higher levels of operational safety. Author (revised by Herner)

A95-95077
CONFUSION ON THE FLIGHT DECK
L. J. ROSENTHAL Battelle, US, R. W. CHAMBERLIN, and R. D. MATCHETTE *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 275-280

In roughly 10 percent of the reports submitted to the Aviation Safety Reporting System (ASRS), reporters allude to confusion on the flight deck. One hundred such reports were examined in detail

to determine how such confusion arises, how it contributes to aviation safety incidents, and how it is ultimately resolved. Particular emphasis was placed on crew interactions as both the source of, and solution to, flight deck confusion. It was determined that most often the confusion relates to what pilots are required to do at a particular point in a flight and that the confusion is often linked to difficulty interpeting or implementing air traffic control (ATC) clearances. The confusion was generally detected and resolved through the combined efforts of pilots and air traffic controllers. Author (Herner)

A95-95078* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE EFFECT OF SCENE CONTENT ON SPEED, TIME, AND DISTANCE PERCEPTION
CYNTHIA A. AWE Western Aerospace Lab., Moffett Field, CA, US and WALTER W. JOHNSON NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 *Columbus, OH Ohio State University April 1993 p. 281-285*
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Helicopter flights performed at low-levels place high demands on pilots; they must simultaneously control the vehicle, avoid obstacles, and navigate. Therefore, pilots must correlate cues viewed in the external scene with information on map in order to maintain their geographical orientation. This is a particularly difficult task when helicopter pilots fly through visually unfamiliar terrain without highly detailed maps. As a result, pilots must often use estimates of elapsed time, distance traveled, and/or average speed in order to maintain a flight path indicated on a map during flight segments when these cues are absent. Therefore, the current study is concerned with the perception of speed, time, and distance, which we assume underlies the ability to orient oneself during these types of flight segments. Author (Herner)

A95-95079* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
USE OF OPTICAL EDGE AND OPTICAL FLOW RATE: INFORMATION IN THE PERCEPTION AND CONTROL OF GROUND VELOCITY
WALTER W. JOHNSON NASA. Ames Research Center, Moffett Field, CA, US and CYNTHIA A. AWE Western Aerospace Lab., Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 286-291
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Previous research (Denton, 1980; Larish & Flach, 1990; Owen, Wolpert, & Warren, 1984; Awe & Johnson, 1989) suggests that people will use one or both of two optical variables as information for the perception and/or regulation of ground velocity. The first variable, global optical flow rate (FR), reflects the angular optical speed, and is proportional to the observer's ground velocity scaled in altitude units, i.e. velocity divided by altitude. Therefore, flow rate is a reliable indicator of ground velocity only under the condition of constant altitude. The second variable, optical edge rate (ER), reflects ground velocity as the frequency at which the optically specified ground edges pass across some optical region. Therefore, edge rate is an accurate indicator of ground velocity when altitude varies, but not when texture density varies. Since both flow rate and edge rate can vary independently of forward ground velocity, accurate ground-velocity control may depend upon using the best optical variable. Author (Herner)

A95-95080
ALTITUDE CONTROL: EFFECTS OF TEXTURE AND GLOBAL OPTICAL FLOW
LEIGH KELLY Wright State Univ., Dayton, OH, US, JOHN M. FLACH Wright State Univ., Dayton, OH, US, SHEILA GARNESS Wright State Univ., Dayton, OH, US, and RIK WARREN Armstrong Lab., OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 292-295
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Conflicting results have been reported by different research groups regarding the superiority of vertical texture over horizontal texture for preventing altitude drift. This experiment combined the ranges of texture and global optical flow used in several of the previous studies in order to understand the source of the conflicting results. Four texture types were combined with four rates of global optical flow and presented to both pilots and non-pilots. The subjects were required to actively control their altitude in the presence of pseudorandom wind disturbances on three axes while viewing each of the texture/flow combinations. A texture by flow interaction was found. For vertical, dot, and square textures, error was low and independent of flow rate. Horizontal texture showed comparably higher error and error increased at higher rates of flow.
Author (Herner)

A95-95081
THE EFFECTS OF TARGET VIBRATION ON CONTRAST SENSITIVITY
WILLIAM F. ADAMS U.S. Military Academy Virginia Polytechnic Inst., Blacksburg, VA, US and ALBERT M. PRESTRUDE U.S. Military Academy Virginia Polytechnic Inst., Blacksburg, VA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 296-301
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The study examined the effects of target vibration upon contrast sensitivity functions in the range of vibratory frequencies from 1 to 10, 15, and 20 Hz. This range was chosen for its ecological validity. Pilots and their displays are normally subjected to vibration in this range. It was originally expected that the contrast sensitivity function (CSF) would decrease directly with increasing vibratory frequency. The authors attempted to determine if vibration could enhance the CSF at some frequencies, hence aiding target detection. The results clearly indicate that moderate levels of target vibration (2 - 9 Hz) increase sensitivity to low spatial frequencies and decrease sensitivity to high spatial frequencies.
Author (revised by Herner)

A95-95084
UNDERSTANDING PILOTS' PERFORMANCE: AN EMPIRICAL SCRUTINY
SIGMAR MALVEZZI Univ. of Sao Paulo, Sao Paulo, Brazil *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 312a-312f
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The present study was carried out as part of a project aimed at creating a new philosophy for the management of pilots in a national airline. The aim of this investigation has been to explore the entire field within which pilots' performance occurs in order to identify the peculiarities, factors and processes to which that performance is linked. By pursuing such an aim, this investigation may be said to be an exploratory study without reference to any specific hypothesis. This paper presents a summary of the results of the scrutiny of the question: What sorts of roles are found in the pilots' job?
Author (revised by Herner)

A95-95096
EXPERIMENTAL EVALUATION OF AGING AND PILOT PERFORMANCE
DIANE T. HYLAND Lehigh Univ., Bethelem, PA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 389-393 Research sponsored by the FAA
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The primary objectives of this project were to: develop a criterion measure of complex pilot performance in a simulator that was objective and quantifiable; develop a test battery of component skills and abilities that could be evaluated as predictor variables and

the simulator criterion measure within a group of 40 pilots varying in age. Pilot age was found to be significantly correlated with simulator performance in the experienced subgroup. Pilot age was also significantly correlated with performance on the predictor tests.
Author (revised by Herner)

A95-95097
PRACTICE EFFECTS ON THE WOMBAT DEVICE
CATHY D. EMERY Univ. of Louisville, Louisville, KY, US and DENNIS H. HOLDING Univ. of Louisville, Louisville, KY, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 394-397
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The authors administered the wondrous original Method for Basic Airmanship Testing (WOMBAT) to commercial air line pilots to determine whether there was a relationship between performance and flight proficiency among experienced pilots. They also sought to examine whether the WOMBAT distinguished between the performances of the air line pilots and a group of novices (college students). They were further interested in ascertaining what learning might take place if a second opportunity were available to a likely candidate. Therefore, the WOMBAT was administered a second time, approximately one week later, to the students to examine longer term training effects. Author (Herner)

A95-95098
DOES DMT (DEFENSE MECHANISM TEST) PREDICT PILOT PERFORMANCE ONLY IN SCANDINAVIA?
MONICA MARTINUSSEN Univ. of Tromso, Norway and TORE TORJUSSEN Hq Defcomnor, Oslo, Norway *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 398-403
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The Defense Mechanism Test (DMT) is a projective personality test, used for measuring psychological defense mechanisms, and for the selection of personnel to high risk occupations. The purpose of this study was to collect evidence for DMT's predictive ability for pilot selection. A local validation study was conducted in Norway with 230 candidates selected for Basic Flying School (BFS). Two DMT measures were correlated against several criteria. The results were mixed. A meta-analysis of all available studies (n = 15) reporting validation results for DMT used in pilot selection, was conducted. The overall average correlation between DMT and pass/fail in undergraduate pilot training was .22. Two subgroups were identified; studies conducted in Scandinavia versus non-Scandinavian studies. A large difference between these two groups in mean correlation was discovered. DMT seems to predict pilot performance only in Scandinavia. Author (Herner)

A95-95100
META-ANALYSIS OF AIRCRAFT PILOT SELECTION PROCEDURES
EUGENE F. BURKE Directorate of Science (Air), London, UK and DAVID R. HUNTER Federal Aviation Administration, Washington, DC, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 413-417
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The 1980's saw a growth in publications of quantitative research reviews with the development of meta-analytic methods. In the context of personnel selection, these methods have come to be known as validity generalization (VG) and this paper uses the approach of VG's principal proponents, Hunter and Schmidt (1990a). The analysis reported in this paper is based on a review of papers published in the literature and in defence organizations' technical reports. The extent to which the sample of studies so identified is representative of the full population of civilian and military selection studies is unknown. The cumulative sample sizes identified through the literature review are substantial and, as the authors are not aware of any previously published VG analysis in this area, we feel that the results have sufficient information value to be of interest to aviation psychologists. Author (revised by Herner)

A95-95101
EFFECTS OF PILOT BACKGROUND AND EXPERIENCE ON AIR COMBAT MANEUVERING (ACM) PERFORMANCE
WAYNE L. WAAG Williams Air Force Base, AZ, US and WILLIAMS B. RASPOTNIK Williams Air Force Base, AZ, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 418-423
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This paper presents the results of exploratory efforts to determine the relationship between air combat performance and variety of background and experience factors. The long-range goal of this work is to develop an understanding of those factors that are predictive of success in air combat. Specifically, the purpose of this investigation was to determine whether information reflecting background and experience could reliably predict performance in a highly controlled air combat simulation environment. Author (Herner)

A95-95102
PERSONALITY TESTS IN AN ENHANCED PILOT SELECTION MODEL
DAVID R. STREET, JR. Naval Aerospace Medical Research Lab., Pensacola, FL, US, DANIEL L. DOLGIN Naval Aerospace Medical Research Lab., Pensacola, FL, US, and KATHLEEN T. HELTON Naval Aerospace Medical Research Lab., Pensacola, FL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 428-433
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The study compares the results of current Navy selection tests, computer-based performance tests (CBPTs), and Pilot Personality Questionnaire (PPQ) to flight grades in the advanced phase of naval flight training. The authors sought to select in desirable characteristics as opposed to previous investigations that emphasized undesirable characteristics. The hypothesis of interest was that certain CBPTs and personality test would improve the prediction of flight-training performance above and beyond the U.S. Navy Aviation Qualification Test/Flight Aptitude Rating (AQT/FAR). The primary goal was to investigate the utility of a broad-spectrum battery in the prediction of advanced naval flight-training performance.
Author (revised by Herner)

A95-95103
A COMPUTERIZED SELECTION TEST FOR CANADIAN FORCES AIR TRAFFIC CONTROLLERS
R. A. BOSWELL Canadian Forces Personnel Applied Research Unit, Ontario, Canada *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 434-438
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A research program to identify potential selection instruments for Canadian military Air Traffic Control (ATC) officers was initiated in 1983 as a result of high failure rates on instrument flight rules (IFR) training courses. The present paper describes the Experimental Air Controller's Test (XACT's) psychometric properties and takes a preliminary look at the ability of the test to predict performance on ATC training. Author (Herner)

A95-95104
VALIDATION OF THE AIR TRAFFIC CONTROL SPECIALIST PRE-TRAINING SCREEN
DANA BROACH FAA Civil Aeromedical Inst., Oklahoma City, OK, US, KRISTEN GOLDBACH Aerospace Sciences, Inc., Fairfax, VA, US, MARY WELTIN Aerospace Sciences, Inc., Fairfax, VA, US, DOUGH ROSENTHAL Aerospace Sciences, Inc., Fairfax, VA, US, ROBERT O'DONNELL NTI, Inc., Dayton, OH, US, and JAN BRECHT-CLARK FAA Headquarters, Washington, DC, US *In* International

Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 439-443

Two validation studies demonstrated that the air traffic control specialist pre-training screen (ATCS/PTS) was a viable replacement for the ATCS Nonradar Screen as the second hurdle in the Federal Aviation Administration's (FAA's) ATCS selection system. The ATCS/PTS was as valid as the current ATCS Nonradar Screen in predicting relative performance in post-Academy ATCS technical training. It was objective and fair. Finally, the ATCS/PTS reduced the cost of selection from $10-12,000 to about $2,000 per candidate.
Author (revised by Herner)

A95-95105
THE DEVELOPMENT OF COGNITIVE TASKS FOR THE SELECTION OF AIR TRAFFIC CONTROL PERSONNEL
GERALD D. GIBB Embry Riddle Aeronautical Univ., Daytona Beach, FL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 444-449

Currently the Federal Aviation Administration uses a multiple-hurdle selection process to screen candidates for air traffic controller training. Previously the system employed a pencil-and-paper aptitude test followed by a nine-week work sample screen. The nine-week program historically eliminated about 40% of the candidate pool. This secondary screen is now replaced with a week-long computer-based test battery. The paper describes the development of several information processing tests constructed primarily on the basis of a cognitive task analysis of the nine-week screen. These tasks were developed for the possible inclusion in the new week-long screening process. Author (Herner)

A95-95106
PERSONALITY SCALES AS PREDICTORS FOR JOB SUCCESS OF AIRLINES PILOTS
HANS-JUERGEN HOERMANN German Aerospace Research Establishment (DLR), Hamburg, Germany and PETER MASCHKE German Aerospace Research Establishment (DLR), Hamburg, Germany *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 450-454

In this study the question is analyzed whether successul career development of airline pilots is related to distinctive personality characteristics. During selection, 274 pilots applying for employment with a European charter airline were examined with a multi-dimensional personality questionnaire. Additionally the applicants were graded in a simulator checkflight. The career development of the pilots was followed for about three years after they were hired by the company. As criteria for job success, objective as well as subjective measures were available. Correlation analyses revealed a consistent pattern of relations.
Author (Herner)

A95-95107
FINDING THE RIGHT STUFF: PERSONALITY STUDIES OF AIRLINE PILOTS
GEORGE SHOUKSMITH Massey Univ., Palmerston, New Zealand *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 455-460

The paper describes three studies which indicate that the good pilot with command potential has and inspires confidence and shows initiative as well as being dependable in most situations. Secondary important characteristics are being calm in all situations, being keen on flying and the job of an airline pilot, as well as showing a high degree of self-discipline. Author (Herner)

A95-95108
HOTT - A CRM COURSE DESIGNED FOR THE HELICOPTER PILOT
JOHN BLANCH Psychavia Ltd., Oxford, UK *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 469-473

In the United Kingdom, the Civil Aviation Authority (CAA) have indicated that training in Flight Deck Management (FDM) is to become a requirement for all AOC (Air Operators Certificate) holders. Large civilian helicopter operators in the United Kingdom have the staff and facilities to run their own courses, but a need was perceived to provide for the smaller operators who were not so blessed. Based on the belief that crew members, many of whom were inherently hostile to the concept of any form of Crew Resource Management (CRM) training, would relate better to a course designed for their particular operating environment, HOTT - Helicopter Oriented Team Training - was developed. Author (revised by Herner)

A95-95109
THE CO-PILOT: PILOT'S 'MATE' OR PILOT-IN-THE-MAKING? A STUDY OF AMBIGUITY AND CONFLICT IN THE COCKPIT
ROGER K. LAMBO and RICHARD T. LAMBO *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 474-477

As early as 1940, the Cambridge psychologist, G. C. Drew (1979), noted the captains of heavy multiengined bombers very rarely allowed their co-pilots to relieve them at the controls. In 1943, the co-pilot was replaced by a flight engineer, or pilot's 'mate', whose job was to assist the pilot in overseeing the engines and managing the fuel consumption. Although the single pilot operation of heavy multiengined aircraft was found acceptable in wartime, it has never been deemed suitable for commercial airliners. At the very least, the co-pilot is still required as a back-up in the event of the incapacitation of the captain. However, the fact that even this level of redundancy has been found lacking, is due to the ambiguity that has surrounded the role of co-pilot, ever since the advent of multi-crew aircraft. Author (revised by Herner)

A95-95110
BEYOND REASON: THE NON JUDGMENTAL PATH OF LEAST RESISTANCE TO GRACEFUL CRM
BERT L. BOTTA Eagle Heart and Associates, St. Louis, MO, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 482-485

The author uses universal principles of optimum human behavior to illustrate safer, more harmonious and ultimately more enjoyable ways to fly aircraft. He makes a case for the use of innate human capabilities that are not frequently equated with proficiency, safety, judgment, reason, logic, performance, standards, etc. He shows how these dormant, in many cases, personal treasures are available to all of us and how they can actually be more effective ways to accomplish more with less effort, in a safer, saner, more joyful and fulfilling manner. Author (Herner)

A95-95111
AVIATION PSYCHOLOGY, GROUP DYNAMICS AND HUMAN PERFORMANCE ISSUES IN ANESTHESIOLOGY
MARK G. EWELL Univ. of Texas Southwestern Medical Center, Dallas, TX, US and RICHARD J. ADAMS Advanced Aviation Concepts, Inc., Jupiter, FL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 499-504

Crew Resource Management (CRM) has been proven to be a valuable method of improving safety and enhancing group interac-

tion in the aviation environment. Many of the concepts developed in CRM can be readily translated to the hospital operating room (OR). Unlike the flight deck where the captain and first officer provide primary and backup crew members, each subgroup of the operating room team brings unique skills to the OR and failure of any of the subgroups could result in failure of the entire OR team in their mission. Further study would allow us to realize the potential for applying CRM-based principles in the operating room and other medical settings. Author (revised by Herner)

A95-95113* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE DYNAMICS OF CRM ATTITUDE CHANGE: ATTITUDE STABILITY
STEVEN E. GREGORICH San Jose State Univ., US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 509-512
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Special training seminars in cockpit resource management (CRM) are designed to enhance crew effectiveness in multicrew air-transport cockpits. In terms of CRM, crew effectiveness is defined by teamwork rather than technical proficiency. These seminars are designed to promote factual learning, alter aviator attitudes, and motivate aviators to make use of what they have learned. However, measures of attitude change resulting from CRM seminars have been the most common seminar evaluation technique. The current investigation explores a broader range of attitude change parameters with specific emphasis on the stability of change between recurrent visits to the training center. This allows for a comparison of training program strengths in terms of seminar ability to effect lasting change. Author (revised by Herner)

A95-95114
EXPERIENTIAL LEARNING IN CREW RESOURCE MANAGEMENT
STEVEN D. LANE Hernandez Engineering, Inc., Denver, CO, US and JACQUELINE S. KORB Hernandez Engineering, Inc., Denver, CO, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 513-516
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The intent of Cockpit or Crew Resource Management (CRM) aims at decreasing human errors which in turn will decrease loss of life and equipment. Most major airlines and several portions of the military provide some type of CRM training. The varieties of CRM training are many. It may consits of a well-planned twenty to thirty hour curriculum, a short one-time exposure, or perhaps an annual refresher. So the question arises as to how we can increase the probability that crew members will remember their CRM training between their short exposures or perhaps their one and only session. Passive modes of learning result in lower learning retention rates. Experiental learning retention rates, however, are substantially higher. Participating in a discussion or exercise may produce seventy percent while performing the actual task can achieve as high as a ninety percent learning retention.
Author (revised by Herner)

A95-95116
LEADERSHIP-BEHAVIOR IN HIGH-TECH-COCKPITS (A 320)
ALOIS FARTHOFER Lufhansa German Airlines, German and REINER W. KEMMLER Lufhansa German Airlines, German *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 522-526
Copyright

A lack of adequate crew-coordination, especially the influence of the captain on crew communication and coordination processes are significant determinants of break-downs in crew performance. The leadership behavior of 24 Lufthansa A 320 pilots was analyzed by interviews. Results indicate that crew coordination seems to be provided by two dimensions of leadership. Effective leadership requires 1. proper management of cognitive, especially verbal and spatial, resources due to an increased demand of information processing capacities in high workload situations, and 2. a balanced working atmosphere (socio-emotional climate). According to these results, recommendations for further selection and training activities are mentioned. Author (Herner)

A95-95117
SELF-ANALYSIS OF LOFT AS A STRATEGY FOR LEARNING CRM IN UNDERGRADUATE FLIGHT TRAINING
GUY M. SMITH Montana State Univ., Bozeman, MT, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 533-537 Research sponsored by the FAA
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The theory of Objective Self-Awareness professes that self-focusing stimuli often forces objective appraisals of oneself that may lead to attitude and behavior change. Since the goal of Crew Resource Management (CRM) and Line-Oriented Flight Training (LOFT) is to influence attitudes and encourage effective teamwork, self-awareness suggests training techniques to achieve these goals. A self-awareness method for teaching CRM skills to undergraduate flight students is described. Crews evaluate their CRM performance in LOFT simulations from berbatim transcriptions and communication analyses of their flight video tapes. Author (Herner)

A95-95118
VALIDATING THE IMPACT OF MAINTENANCE CRM TRAINING
JAMES C. TAYLOR Univ. of Southern California, Los Angeles, CA, US, MICHELLE M. ROBERTSON Univ. of Southern California, Los Angeles, CA, US, RUSSELL PECK Continental Airlines, Inc., Houston, TX, US, and JOHN W. STELLY Continental Airlines, Inc., Houston, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 538-542 Research sponsored by FAA
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An effective training program focusing on behavioral and attitudinal changes involving team-related concepts has emerged and grown in the aviation setting. This type of communication training includes several teamwork concepts, such as communication skills, self-knowledge, situational awareness, and assertiveness skills. This paper describes an evaluation of the effectiveness of a carrier's communication and team concepts training program, called Crew Coordination Concepts (CCC), created and developed by the company for its maintenance technical operations managers.
Author (revised by Herner)

A95-95119
LOS/LOFT DEBRIEFING SKILLS AND TECHNIQUES
NEIL JOHNSTON Trinity College, Dublin, Ireland *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 542a-542f
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Line Operational Simulation (LOS) and Line Oriented Flight Training (LOFT) provide pilots with an opportunity for experienced-based 'experiential' learning. This paper reviews aspects of debriefing as it relates to experiential learning and is exclusively directed to LOS/LOFT debriefing; it is not concerned with the development or design of LOS or LOFT scenarios, nor with the actual conduct of such scenarios. Author (Herner)

A95-95120* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WHITHER CRM? FUTURE DIRECTIONS IN CREW RESOURCE MANAGEMENT TRAINING IN THE COCKPIT AND ELSEWHERE

ROBERT L. HELMREICH NASA/Univ. of Texas/FAA, Austin, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 543-548 Research sponsored by FAA
(Contract(s)/Grant(s): NCC2-286)

The past decade has shown worldwide adoption of human factors training in civil aviation, now known as Crew Resource Management (CRM). The shift in name from cockpit to crew reflects a growing trend to extend the training to other components of the aviation system including flight attendants, dispatchers, maintenance personnel, and Air Traffic Controllers. The paper reports findings and new directions in research into human factors.
Author (Herner)

A95-95121* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
POSITION-SPECIFIC BEHAVIORS AND THEIR IMPACT ON CREW PERFORMANCE: IMPLICATIONS FOR TRAINING
J. RANDOLPH LAW NASA/Univ. of Texas/FAA, Austin, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 549-555 Research sponsored by FAA
(Contract(s)/Grant(s): NCC2-286)

The present study was motivated by results from a preliminary report documenting the impact of specific crewmembers on overall crew performance (Wilhelm & Law, 1992), and a cross-airline cross-fleet project investigating human factors behaviors of commercial aviation flightcrews (Helmreich, Butler, Whilhelm, & Lofaro, 1992). The purpose of the current investigation is to study how position-specific behaviors impact flightcrew performance, and how these position-specific behaviors differ between two airlines and two flying environments. Implications for training will also be addressed.
Author (Herner)

A95-95122* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CAPTAIN UPGRADE CRM TRAINING: A NEW FOCUS FOR ENHANCED FLIGHT OPERATIONS
WILLIAM R. TAGGART NASA/UT/FAA, Austin, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 556-560 Research sponsored by FAA
(Contract(s)/Grant(s): NCC2-286)

Crew Resource Management (CRM) research has resulted in numerous payoffs of applied applications in flight training and standardization of air carrier flight operations. This paper describes one example of how basic research into human factors and crew performance was used to create a specific training intervention for upgrading new captains for a major United States air carrier. The basis for the training is examined along with some of the specific training methods used, and several unexpeced results.
Author (Herner)

A95-95123* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CROSS-CULTURAL ATTITUDES OF FLIGHT CREW REGARDING CRM
ASHLEIGH MERRITT NASA/Univ. of Texas/FAA, Austin, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 561-566 Research sponsored by FAA
(Contract(s)/Grant(s): NCC2-286)

This study asks if the Cockpit Management Attitude Questionnaire (CMAQ) can detect differences across countries, and/or across occupations. And if so, can those differences be interpreted? Research has shown that the CMAQ is sensitive to attitude differences between and within organizations, thereby demonstrating its effectiveness with American populations. But the CMAQ was originally designed by American researchers and psychometrically refined for American pilots. The items in the questionnaire, though general in nature, still reflect the ubiquitous Western bias, because the items were written by researchers from and for the one culture. Recognizing this constraint, this study is nonetheless interested in attitudes toward crew behavior, and how those attitudes may vary across country and occupation.
Author (Herner)

A95-95125
THE IMPACT OF AUTOMATION ON CREW COMMUNICATION AND PERFORMANCE
CLINT BOWERS Univ. of Central Florida, Orlando, FL, US, JOHN DEATON Naval Training Systems Center, Orlando, FL, US, RANDY OSER Naval Training Systems Center, Orlando, FL, US, CAROLYN PRINCE Naval Training Systems Center, Orlando, FL, US, and MICHELLE KOLB Naval Training Systems Center, Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 573-577

The nature of modern flight is such that it requires multiple crew members to operate complex systems in a coordinated fashion. The task imposes a level of interdependency upon the crew such that it would be difficult for any one member to complete the entire task without assistance from others. Yet, despite the requirement for communication and coordination inherent within the task, there is relatively little guidance in the scientific literature to suggest how to optimize these interactions to result in effective performance. The present manuscript attempts to contribute to this understanding by describing empirical data related to the impact of one increasingly important task factor, cockpit automation, upon crew communication and performance.
Author (revised by Herner)

A95-95127* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF COMMUNICATION IN THE STANDARD VERSUS AUTOMATED AIRCRAFT
ELIZABETH S. VEINOTT San Jose State Univ. Foundation, San Jose, CA, US and CHERYL M. IRWIN San Jose State Univ. Foundation, San Jose, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 584-588

Past research has shown crew communication patterns to be associated with overall crew performance, recent flight experience together, low-and high-error crew performance and personality variables. However, differences in communication patterns as a function of aircraft type and level of aircraft automation have not been fully addressed. Crew communications from ten MD-88 and twelve DC-9 crews were obtained during a full-mission simulation. In addition to large differences in overall amount of communication during the normal and abnormal phases of flight (DC-9 crews generating less speech than MD-88 crews), differences in specific speech categories were also found. Log-linear analyses also generated speaker-response patterns related to each aircraft type, although in future analyses these patterns will need to account for variations due to crew performance.
Author (Herner)

A95-95128
THE FUTURE OF LOFT SCENARIO DESIGN AND VALIDATION
WILLIAM R. HAMMAN United Airlines, Denver, CO, US, THOMAS L. SEAMSTER Carlow International Inc., Falls Church, VA, US, KEVIN M. SMITH United Airlines, Denver, CO, US, and RONALD J. LOFARO FAA, Atlantic City, NJ, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 589-594

(Contract(s)/Grant(s): DTFA01-91-C-00038)

The use of Line-Oriented Flight Training (LOFT) as a training program began in 1975. LOFT was an intuitive and logical advancement to training programs for several reasons. The technology and hardware for total simulation improved to allow high fidelity simulation of the line environment. The issues of human factor errors as they relate to management and leadership in the flight deck are an important part of the analysis of the use of total simulation in training and of the introduction of Line Operational Simulation using LOFT. A new framework is presented for the development of LOFT scenarios based on the concept of an event set, a group of related events which are part of the senario and are inserted in the LOFT session for specific Crew Resource Management (CRM) and technical training objectives. Author (revised by Herner)

A95-95129
THE ROLE OF LOFT IN CRM INTEGRATION

RONALD J. LOFARO FAA, Atlantic City, NJ, US and KEVIN M. SMITH United Airlines, Denver, CO, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 595-600

Crew Resource Management (CRM) Integration targets the interrelationships between flightcrew human factor and technical 'flying' skills and their combined contribution to mission success. CRM Integration is not the placing of CRM training components, in a piecemeal fashion, within an existing flightcrew training curriculum. The purpose of Line-Oriented Flight Training (LOFT) is to expose the crew to a 'mission realistic' environment and engage the crew in a set of meaningful activities that directly transfer to actual line operations. Further, to provide high instructional utility, the LOFT needs to target the interrelationships between human factor and technical (flight control) skills and their combined contribution to mission success. This paper examines the LOFT as an instrument for comprehensive crew training and outlines a process for the design of an advanced LOFT curriculum in which crew skills are integrated. Author (revised by Herner)

A95-95130
CRM ASSESSMENT AND INSTRUCTOR KNOWLEDGE STRUCTURES

THOMAS L. SEAMSTER Carlow International Inc., Falls Church, VA, US, KEVIN M. SMITH United Airlines, Denver, CO, US, WILLIAM HAMMAN, R. United Airlines, Denver, CO, US, RONALD J. LOFARO FAA, Atlantic City, NJ, US, and WILLIAM A. MCDOUGALL Delta Air Lines, Atlanta, GA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 601-605
(Contract(s)/Grant(s): DTFA01-91-C-00038)

The prototype Crew Resource Management Assessment (CRMA) expert system is being developed in recognition of the significant role that Line-Oriented Fligth Training (LOFT)-based CRM assessment plays in an effective CRM training program. As part of the development process, the concept sorting data of recurrent LOFT instructors were captured and represented in the form of hierarchical clusters. The resulting representations were used to identify the knowledge structures of the more experienced recurrent training instructors. These knowledge structures were analyzed to identify the primary clusters used in an efficient CRM assessment. The combined results across all six instructors are prsented and discussed. Then, the knowleged structures of the more experienced instructors are detailed with an emphasis on the key CRM assessment clusters. The results of this series of cluster analyses established two important elements of CRM assessment. First, the findings provided a number of insights related to the experience level of the instructors performing CRM assessment. Second, the results helped to identify the four primary clusters that experienced instructors use in the assessment of CRM and the management of LOFT sessions. Author (Herner)

A95-95131
CROSS-CULTURAL PERSPECTIVES IN HUMAN FACTORS TRAINING: THE LESSONS FROM THE ICAO HUMAN FACTORS PROGRAMME

DAN MAURINO International Civil Aviation Organization (ICAO), Montreal, Canada *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 606-610

The International Civil Aviation Organization (ICAO) has identified particular issues, largely culture-related — although sometimes context-related —, with potential implications on the outcome of Human Factors training within different contexts. From a practitioner's point of view, these cultural and contextual issues are deemed of value in orienting the direction of Human Factors training targeted at other than North American audiences. ICAO's experience also supports the conclusion that the effectiveness of Human Factors training may be diminished — or even denied altogether — by the context within which such endeavours take place. While the symptoms of certain safety deficiencies may appear similar on the surface, underlying cultural and contextual factors may dictate radically different solutions. In fact, safety deficiencies that could be addressed by Human Factors training in North America may not be effectively addressed at all by training in other regions of the world. Author (revised by Herner)

A95-95133
ANXIETY AND EYE-HANDS-LEGS COORDINATION IN YOUNG PILOTS

JAN TERELAK Military Inst. of Aviation Medicine, Warsaw, Poland *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 629-633

An experimental study examining the relationship between anxiety and psychomotor performance is presented. Young pilots (boys) within the age range of 16-17 served as subjects. Level of anxiety was determined with Spielberger's state-trait anxiety inventory (STAL). Psychomotor performance was examined by means of the Bryans SMA-3 Coordinometer. A relationship was found between anxiety as a personality trait and one of the indicators (skill increment) of learning efficiency of the psychomotor task. It was also found that state anxiety has a primarily negative effect on the structure of psychomotor activity at its initial stage of eye-hand-legs coordination task learning. Author (Herner)

A95-95141
IMAGERY IN AVIATION: PILOT TRAINING

FRANCIS S. BENNETT Embry-Riddle Aeronautical Univ., Prescott, AZ, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 677-681

Instrument flight students from the Embry-Riddle flight training program were given four hours of imagery training and practice as part of their ground school program prior to actual flight. Students were scheduled for a computer-scored simulator ride at the beginning of their final phase of flight. Expectations were that students who received the imagery training would have better performance scores in the simulator ride. Scored responses to questionnaires were expected. To give further evidence that imagery training would improve overall performance of the pilots. The subject students as compared with their controls showed higher scores across the board in performance, stress control, judgement and self esteem. The process and validity of these results will be discussed in this paper. Author (Herner)

A95-95142
AEROMEDICAL PSYCHOLOGY TRAINING
STEPHEN V. BOWLES U.S. Army School of Aviation Medicine, Fort Rucker, AL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 682-683

There has been ample evidence to indicate that the psychological status of the individual plays a significant role in aviation safety, operational readiness, and health and fitness of aviation personnel. The Aeromedical Psychology Training Course has been developed to provide selected clinical psychologist with specialized trainng in the fundamentals and aplication of clinical aviation psychology in aviation medicine. The aeromedical psychology training course was implemented in FY 92 under the sponsorship of the AMEDD professional Post-graduate Short Course program, and hosted by the U.S. Army School of Aviation Medicine (USASAM), Fort Rucker, Alabama. This paper will discuss the objectives of the course, course curriculum and skills an aeromedically trained psychologist may offer aviation medicine. Author (Herner)

A95-95143
THE HIDDEN MESSAGES OR A GESTALT VIEW OF PILOT TRAINING
DENNIS CHRISTLEY Univ. of Newcastle, NSW, Australia *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 684-690

The paper prevents a model based on Gestalt theory that is intended to go some way towards recognizing that the people we train do have values, beliefs, attitudes and emotions, and that if we ignore these we will be apt to give false messages. These false messages may influence our trainees' decision making and lead to violations or 'bad' decisions, rather than simple errors or slips. The model suggests that we could train towards a Gestalt, a model of a professional pilot that includes more than just the skills and knowledge required for the role. It is hoped that the model is pro-active, and that it may help to prevent some incidents or accidents.
Author (Herner)

A95-95144
WINDSHEAR EDUCATION IN THE AVIATION INDUSTRY - AN OVERVIEW
REO W. PRATT *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 702-706

Implementation of windshear training programs may have resulted in a decline in windshear related accidents, but much can be done to refine training and enhance pilot understanding of avoidance strategies. Four significant factors were extracted from a study of nine selected accidents, and are offered as avoidance cues. Suggestions for modifying training strategies in simulator and class room are offered. Author (Herner)

A95-95145
THE NEED FOR A BASIC PSYCHOLOGICAL CURRICULUM TO AUGMENT CRM TRAINING
E. M. SUAREZ Clinical and Consulting Psychologist, Coral Gables, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 707-710

Over the past decade the commercial airline industry has increasingly embraced the Cockpit Resource Management (CRM) model as being a necessary and essential part of pilot training. Indeed, the economic and regulatory realities of the past decade have created or intensified stressors for pilots, further highlighting the need for safety related training such as CRM. But while CRM has become an established part of pilot training in commercial aviation there is still an observable gap between CRM curriculum and actual pilot performance within and beyond the cockpit. This paper will discuss the need for establishing a basic psychological curriculum that will fill this gap in knowledge and provide the pilot with a basic level of psychological understanding that will then serve as a basis for enhancing and extending CRM principles within and beyond the cockpit. Author (Herner)

A95-95146
NEW DIAGNOSTIC TOOLS FOR MEASURING LEARNING BEHAVIOR IN PILOT TRAINEES
LYNN M. HUNT Massey Univ., New Zealand *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 711-716

In recent times a number of research tools have evolved to measure approaches to learning. These tools have been used to demonstrate that there are at least three different approaches that a student may take to learning, and that the particular approach chosen may affect the quality of the learning outcome. Now that research has established the link between the type of learning strategies students use and how well they learn content, it is time to provide students and instructors with the diagnostic tools that will direct their efforts to better learning. This paper is an attempt to explain the limitations of some existing tools and provide the specifications for a diagnostic instrument.
Author (revised by Herner)

A95-95147
SEVEN AERONAUTICAL PYRAMIDES
JOSE MIRABAL *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 717-720

The difficulty of conceptualizing and teaching flight safety motivated the author to develop an educational aid to analyze, visualize and discuss flight safety. These are seven aeronautical pyramids which illustrate in a symbolic, spatial and visual manner different aspects of flight safety, and they are easy to memorize.
Author (revised by Herner)

A95-95148
EMERGENCY MANOEUVRE PILOT TRAINING IN A LOW-COST FLIGHT SIMULATOR
J. V. SVOBODA Concordia Univ., Montreal, Quebec, Canada, RUTH M. HERON Transportation Development Center, Montreal, Quebec, Canada, and H. WEINBERG Simon Fraser Univ., Burnaby, BC, Canada *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 721-725

The study is designed to assess experimental approaches to tests of the training hypothesis, especially as they concern use of a Concordia-designed low-cost microprocessor-based interactive flight simulator, in combination with electroencephalographic (EEG) measurement techniques. As the study is still in progress at time of writing, this report is confined to informing readers of the direction of the research. Following a brief introduction, the paper provides a description of the simulator system and, subsequently, of training and test scenarios, performance and workload measures, and experimental procedures. In conclusion, expected results are outlined, and the potential of the simulator for quasi-transfer general aviation (GA) pilot training research is discussed. Author (Herner)

A95-95149
SOME IMPLICATIONS OF PILOTS' APPROACHES TO LEARNING
ROSS TELFER Univ. of Newcastle, Australia, PHILLIP MOORE Univ. of Newcastle, Australia, and ROBERT SCOTT *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-

29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 726-731
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The structure of learning in aviation is more centralized than in schools and the mission in aviation is to provide knowledge and skills and recognized professional accountability as opposed to schools where the transmission of culture, the preparation of individuals to live in a society, are major goals. The focus in aviation is on the transfer of learning compared to delayed performance at maturity as an educated member of society. There is less flexibility for those learning in aviation, either at ab initio or endorsement levels, due to regulatory requirements. The relationships between approaches to learning and performance in aviation have now been examined in several different populations. The first study examined approaches to learning (and their relationships with learning outcomes) in a sample of pilots who were training to gain their commercial pilots licence (ab initio pilots). The second gained data from a sample of experienced pilots who were undertaking retraining (Pilots Undergoing Initial Training - PUIT), while the third study involved interviews with a small sample of experienced commercial jet pilots. The concluding study examined ways in which approaches to learning in experienced pilots might be more appropriately assessed, leading to the development of the Pilot Learning Process Questionnaire.
Author (revised by Herner)

A95-95150
TEACHING AVIATION SAFETY: A NEW METHODOLOGY
WILLIAM K. MCCURRY Indiana State Univ., Terre Haute, IN, US and JULIE A. YATES Indiana State Univ., Terre Haute, IN, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 732-736
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A proposal including content and methodology for Aviation Risk Analysis, an aviation safety course at Indiana State University (ISU), will be presented in this paper. The goal of this course will be teaching pilots how to break the chain of events that leads to an aviation accident. A description of the procedure and results of a preliminary study done to test the proposed methodology will be discussed. Author (Herner)

A95-95151
HUMAN FACTORS TRAINING FOR THE NEW JOINT EUROPEAN (JAA) PILOT LICENCES
NEIL JOHNSTON Trinity College, Dublin, Ireland *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 736a-736f
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This paper reviews the European Joint Aviation Authorities (JAA) proposals for human factors training. The JAA plans to mandate both human factors knowlege and skill training for the initial issue of all future pilot licences. This paper briefly and critically reviews the JAA proposals, as contained in the fourth draft of the JAA Flight Crew Licensing proposals. Author (Herner)

A95-95152
AN INCREMENTAL TRANSFER STUDY OF SCENE DETAIL AND FIELD OF VIEW EFFECTS ON BEGINNING FLIGHT TRAINING
GAVAN LINTERN Univ. of Illinois, Savoy, IL, US, HENRY L. TAYLOR Univ. of Illinois, Savoy, IL, US, JEFFERSON M. KOONCE Univ. of Central Florida, Orlando, FL, US, and DONALD A. TALLEUR Univ. of Illinois, Savoy, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 737-742
(Contract(s)/Grant(s): DTFA01-90-C-00045)
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Ninety-six male students and 32 female students are to be tested in a transfer of training study in which a simulator with a visual system is being used to teach pattern flight and landing. Data collection is still in progresss. The results reported here are from 34 male students who have been tested under factorial combinations of scene detail, field of view, and amount performance in the landing pattern were used to assess short-term transfer effects, and the number of practice landings required by the student prior to release for solo were used to assess longer-term transfer effects. Low fidelity configurations of the simulator did not always result in degraded transfer. A mix of instrument training with a side field of view. A decrement in longer-term transfer relative to the high fidelity configuration of a high detail scene and wide field of view was observed only when both low-fidelity options were combined in training. In addition, a discrepancy between short-term and longer-term transfer trends indicates the need to examine transfer effects at different times after training. Author (Herner)

A95-95153
USES OF PART-TASK TRAINERS IN INSTRUMENT FLIGHT TRAINING
SYBIL I. PHILLIPS Univ. of Illinois, Savoy, IL, US, CHARLES L. HULIN Univ. of Illinois, Savoy, IL, US, and PAUL J. LAMERMAYER Univ. of Illinois, Savoy, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 743-746
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This study reports data relevant to the uses of a PC-based instrument training software package in a beginning instrument training course. In the initial phase of the research, 14 subjects received 10 hours of instruction in a ground-based flight simulator (ILLIMACs). Seventeen subjects received 10 hours of training on the ELITE, a PC-based, instrument training system. Both groups received 18.5 hours of flight training in a BE-19/BE-23, and 1.5-hour checkride in the same type of aircraft. The results of this phase of the research indicated the following rates of passing the checkride on the first attempt administered at the end of the semester of training (46% for the ILLIMAC group versus 73% for the ELITE group). Those who failed on the first attempt were given additional training and all those subjects passed the checkride on the second attempt. Four subjects were not recommended for the checkride. The research results confirm the usefulness of part-task trainers as supplements to flight training and as substitutes for training in flight simulators. Cost and flexibility advantages of the PC-base system over most flight simulators suggest a great deal is to be gained from training programs that are designed to incorporate training on specific parts of the overall task of flying aircraft under a variety of environmental conditions. In addition to the obvious uses of part-task training systems to teach instrument flight skills, several innovative uses of the system as a sophisticated electronic chalkboard have been explored and will be reported in this paper. Author (Herner)

A95-95154
THE INTEGRATION OF VISUAL SIMULATION IN BEGINNING FLIGHT TRAINING
DONALD A. TALLEUR Univ. of Illinois, Savoy, IL, US, GAVAN LINTERN Univ. of Illinois, Savoy, IL, US, and JAMES R. PONDER Univ. of Illinois, Savoy, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 747-752
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In the project's first stage, one student was taken through the experimental training course. The instructor was given the goal of accomplishing as much of the training as possible in the research simulator. Flight time was to be used to verify progress and to complete the instruction of skills that could not be taught to require standards in the simulator. Ten hours of extra training were given in the research simulator. Our experience with this first student led to adjustments in the training program. Work has commenced on testing five students in the special instructional programs and five control students from the standard course. Here we report on the

progress of a small number of students from each of the two groups. The goal of this program is to develop an experimental procedure that will permit a comprehensive investigation of the benefits that accrue from the use of a simulator with a visual system in beginning flight training. Author (Herner)

A95-95155
SCENE CONTENT, FIELD OF VIEW AND AMOUNT OF TRAINING IN FIRST OFFICER TRAINING
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(Contract(s)/Grant(s): DTFA01-90-C-00045)

Thirty-six subjects are to be tested in a transfer of training study which uses a simulator to teach take offs, closed patterns, and instrument landing systems (ILS) procedures in an advanced multi-engine aircraft. The amount of visual simulation training was manipulated (0, 50% and 100%) as was scene detail (low and high) and field of view (narrow and wide). Four experimental sessions of one hour each were conducted in the simulator and three hours of flight training in the aircraft were used to test for transfer. The results indicated that the amount of visual simulator training was inversely related to aircraft landing attitude and follow through. Variations in scene detail were not significant. A wide field of view produced an advantage over a narrow field of view on transfer. A low-detail scene and a wide field of view was superior to all other combinations. Author (Herner)

A95-95156
THE DEVELOPMENT OF AIRCREW COORDINATION BEHAVIORS
CLINT A. BOWERS Univ. of Central Florida, Orlando, FL, US, CURT C. BRAUN Univ. of Central Florida, Orlando, FL, US, BARBARA E. HOLMES Univ. of Central Florida, Orlando, FL, US, BEN B. MORGAN, JR. Univ. of Central Florida, Orlando, FL, US, and EDUARDO SALAS Naval Training Systems Center, Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 758-761

The specific-skill approach to aircrew coordination training represents a departure from traditional training programs in that it emphasizes the role of behavioral practice and feedback. Investigations of the development of crew coordination behaviors may also assist in the evaluation of crews under training. One difficulty in evaluating training effectiveness regards when such evaluation should take place. It is likely that the specific behaviors must be assimilated by the team during the developmental process. Therefore, the effects of training may be somewhat obscure for some period of time following training. The present research sought to investigate the development of coordination behaviors in teams of novices by using a longitudinal research design. This paper focuses on the change of communication patterns within three crews with different performance trends over time. It is believed that this effort will serve to create useful hypotheses for more intensive studies of team development in aviation. Author (revised by Herner)

A95-95157
A METHOD FOR SPECIFYING OBSERVATIONS IN TEAM TRAINING
MICHAEL T. BRANNICK Univ. of South Florida, FL, US, ASHLEY PRINCE Univ. of South Florida, FL, US, and CAROLYN PRINCE Naval Training Systems Center, Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 762-765

Part of the difficulty in training teams stems from real problems in deciding what to observe. A second difficulty results from having to give feedback about observed behavior to team members to reinforce or correct teamwork. The current paper describes how we developed the items on which to give feedback, how well the judges agreed about student pilot (SP) performance on the items, and the results of giving feedback and gaining experience on subsequent performance. The current study focused on specific team behaviors related to communication, decision making, assertiveness, and situational awareness. We believed that observations could be delineated before team exercise that would be relevant to various team skills and that would be reliably evaluated by instructors and observers. We hypothesized that student show received feedback on team skills would show performance superior to students who did not receive feedback. We also speculate that simply having the opportunity to practice some team skills might improve performance. Author (Herner)

A95-95158
A PC-BASED SYSTEM TO ENHANCE DEVELOPMENT OF SCENARIOS: ASCEND (ANALYSIS OF SCENARIO DEMANDS) SYSTEM
RANDALL L. OSER Naval Training Systems Center, Orlando, FL, US and MARIA MAZZARA Naval Training Systems Center, Orlando, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 766-769

Line-oriented scenarios performed in simulators have been increasingly used to conduct technical skill training, crew resource management (CRM) training, and aircrew human factors research. A research and development project was initiated to investigate, design, and evaluate a PC-based 'proof of concept' system. The objective of the 'proof of concept' system was to present subject matter experts with the scenario events which the developer is considering incorporating into a training or research scenario. Based on the presentation of the scenario events, subject matter experts could provide ratings to assess whether the senario would actually meet its intended objectives. The analysis of SCENario Demands (ASCEND) system was developed as a 'proof of concept' system. Although many characteristics of scenarios can be evaluated, this discussion will focus on the coordination to demands of the scenario. The paper will (1) provide an overview of the purpose and development of the ASCEND system, (2) describe an investigation used to determine whether the system could provide a reasonable platform for scenario evaluation, (3) discuss preliminary reactions to the system from subject matter experts, (4) outline a future validation effort which will be used to evaluate the utility of the system for scenario develoment, and (5) present other potential applications of the system. Author (revised by Herner)

A95-95160
DESIGNING COMPUTER-BASED INSTRUCTIONAL SIMULATION: INSTRUCTIONAL CONTROL AND PART-WHOLE-TASK TRAINING
JOSEPH S. MATTOON Armstrong Lab., Williams AFB, AZ, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 776-781

Instructional control in the context of simulation training is a complex variable that may interact with a number of other task-realted variable. Program-controlled strategies are probably the best choice for computer-assisted instructional simulation (CAIS), because they reduce the overall load on working memory during instruction and enable learners to devote all their dognitive resources to the learning tasks. Part-task training appears to be the best choice for teaching tasks. Tasks can be decomposed into a number of subtasks, practiced separtately, and progressively recombined to enable learners to understand the task and develop the subskills they need to execute and practice the entire task. Author (revised by Herner)

A95-95165
A TRAINING APPROACH FOR HIGHLY AUTOMATED ATC SYSTEMS
HUGH BERGERON FAA, Moffett Field, CA, US and HAROLD HEINRICHS Decisions Systems, Los Altos, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 805-8811

Air traffic controller training is a well-defined, formalized process that has served the needs of the FAA for many years. This training, however, was developed before the advent of new advanced highly automated Air Traffic Control (ATC) systems. This paper discusses the development of training for an automated, computer based system called the Center-TRACON Automation System (CTAS). CTAS consists of three separate but integrated automation tools: Traffic Management Advisor (TMA) for use in the Traffic Management Units at both enroute traffic control facilities and TRACONs, Descent Advisor (DA) for use by enroute controllers, and Final Approach and Spacing Tool (FAST) for use by radar controllers at high density airports. Each tool of the CTAS is being refined and further developed during the deployment process. It is proposed that the training approach developed for CTAS be considered as a model for future, highly automated (ATC) systems.
Author (revised by Herner)

A95-95167
AIR TRAFFIC CONTROLLER RESOURCE MANAGEMENT
DUDLEY P. TENNEY Airline Captain, ret., Tulsa, OK, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 817-820

The Federal Aviation Administration (FAA) has a National Simulation Capability (NSC), which has been used to test air traffic control innovations. Expanding it to teach human factors to their controllers is only a matter of logistics. Using components of the NSC, numerous simulations have been conducted in which data from actual aircraft flight tracks, simulator flight tracks and computer generated (target) flight tracks have been displayed on air traffic control radar screens. The full performance level controllers involved in these tests have found the simulations to be very realistic. The use of high fidelity ATC simulators could lead to a new type of controller-pilot interface, which will revolutionize pilot crew resource management and launch air traffic controller resource management (ATCRM). Author (revised by Herner)

A95-95168* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ATTENTION IN A MULTI-TASK ENVIRONMENT
ANTHONY D. ANDRE NASA. Ames Research Center, Moffett Field, CA, US and SUSAN T. HEERS NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 821-826 (Contract(s)/Grant(s): NCC2-486)

Two experiments used a low fidelity multi-task simulation to investigate the effects of cue specificity on task preparation and performance. Subjects performed a continuous compensatory tracking task and were periodically prompted to perform one of several concurrent secondary tasks. The results provide strong evidence that subjects enacted a strategy to actively divert resources towards secondary task preparation only when they had specific information about an upcoming task to be performed. However, this strategy was not as much affected by the type of task cued (Experiment 1) or its difficulty level (Experiment 2). Overall, subjects seemed aware of both the costs (degraded primary task tracking) and benefits (improved secondary task performance) of cue information. Implications of the present results for computational human performance/workload models are discussed. Author (Herner)

A95-95169* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CREW PERFORMANCE AND COMMUNICATION: PERFORMING A TERRAIN NAVIGATION TASK
VERNOL BATTISTE NASA. Ames Research Center, Moffett Field, CA, US and SUSANNE DELZELL San Jose State Univ. Foundation, San Jose, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 827-832

A study was conducted to examine the map and route cues pilots use while navigating under controlled, but realistic, nap-of-the-earth (NOE) flight conditions. US Army helicopter flight crews were presented a map and route overlay and asked to perform normal mission planning. They then viewed a video-recording of the out-the-window scene during low-level flights, without the route overlay, and were asked periodically to locate their current position on the map. The pilots and navigators were asked to communicate normally during the planning and flight phases. During each flight the navigator's response time, accuracy, and subjective workload were assessed. Post-flight NASA-TLX workload ratings were collected. No main effect of map orientation (north-up vs. track-up) was found for errors or response times on any of the tasks evaluated. Navigators in the north-up group rated their workload lower than those in the track-up group. Author (revised by Herner)

A95-95170
THE DEVELOPMENT OF SUBJECTIVE MEASURE OF WORK UNDERLOAD
C. D. BRABY Cranfield Inst. of Tech., Bedfordshire, UK *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 833-837

This paper describes the development of a subjective technique to assess work underload among civil airline pilots. Earlier work at the Applied Psychology Unit which resulted in the definition of a group of 22 states which may be experienced during underload is presented. The findings of further research which was undertaken to examine the underlying factor structure of the twenty-two states are reported. Two factor solutions are presented to reflect the responses to the states given two flight scenarios relating to the qualitative and quantitative dimensions of work underload. A total of 10 factors are identified relating to 'Task Involvement', 'Stress', 'Activation', 'Qualitative underload', Quantitative Underload', and 'Control'. Similarities and differences between the two solutions are described and methods of scoring the responses to the items on the Subjective Underload Technique outlined. Author (Herner)

A95-95171* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIGATIONAL DEMANDS OF LOW-LEVEL HELICOPTER FLIGHT
SUSANNE DELZELL San Jose State Univ. Foundation, San Jose, CA, US and VERNOL BATTISTE NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 838-842

The present study was designed to assess the verbal references to map, terrain, direction, and position, that navigators and pilots communicate during a simulated low-level flight. Two-person crews were asked to communicate normally while negotiating six short flight missions that varied widely in regard to map-terrain characteristics. Half of the crews performed the exercises with fixed, north-up maps and the other half used movable maps that were adjusted to maintain a track-up correspondence to the flight route. An analysis was performed to compare differences in crew communication patterns between map orientations, characteristics, and navigation tasks. The results showed differences in the frequency of

communication across categories for map characteristics but not for map orientations or tasks. A difference in the proportion of communications between pilot and navigator occurred when crew were lost. Pilots communicated more than navigators when crews were lost and the reverse was true when crews were not lost. The results support and extend findings from a distance error performance analysis performed on the same flight missions.
Author (Herner)

A95-95172
STABILIZATION OF PERFORMANCE ON A COMPUTER-BASED VERSION OF THE MULTIPLE TASK PERFORMANCE BATTERY
CRYSTAL CRUZ Federal Aviation Administration, Oklahoma, OK, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 743-848

The Multiple Task Performance Battery (MTPB) was first designed in the late 1950s to investigate issues related to aircraft crew performance in a synthetic work environment. In 1990, Dr. Henry Mertens completed development of a computer-based version of the MTPB. Five specific tasks were included in the computerized battery and can be variously combined to alter experimental workload conditions. The battery has provided an established approach to an intrinsically motivating synthetic work situation requiring time-shared performance of several tasks under varying workload conditions. Author (revised by Herner)

A95-95173
THE OPTIONS OF PILOTS FLYING AUTOMATED CORPORATE AIRCRAFT WITH REGARD TO THEIR PERCEIVED WORKLOAD
PATRICK C. GUIDE Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, JOHN A. WISE Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, DAVID W. ABBOTT Univ. of Central Florida, Orlando, FL, US, and LANNY J. RYAN Decision Services International, Port Orange, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 849-853
(Contract(s)/Grant(s): DTFA01-91-C-00042)

High levels of automation in complex human-machine systems can have negative consequences on system performance. Corporate aviation is experiencing increased automation. It would appear that it may be more susceptible to some of the negative effects of automation. Even though pilots were very enthusiastic about the automated cockpits, they expressed mixed feelings about workload. While many pilots felt automation has reduced the overall workload, others thought that it had been dramatically increased. Although pilots viewed workload during approach/landing as somewhat moderate, their perceptions of workload increased with aircraft level of automation. Author (revised by Herner)

A95-95174* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MEASUREMENT OF TASKLOAD IN THE ANALYSIS OF AIRCREW PERFORMANCE
IRENE V. LAUDEMAN Univ. of California at Berkeley, Berkeley, CA, US and EVERETT A. PALMER NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 854-858

The objective of the study was to perform a quantitative analysis of a high workload portion of a full mission flight simulation in order to test the hypothesis that taskload area is a valid, objective measure of workload management. This methodology provides a tool for the researcher attempting to quantify the management of workload in a complex environment. The researcher can then produce a reliable quantitative evaluation of behavior related to workload management.
Author (revised by Herner)

A95-95175
SUBJECTIVE WORKLOAD PROFILE
PAMELA S. TSANG Wright State Univ., Dayton, OH, US and VELMA L. VELAZQUEZ Mead Data Central, Miamisburg, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 859-864

The paper examines three procedures that represent different approaches to subjective workload assessment. The psychophysical and Bedford procedures are both unidimensional procedures. In contrast, the workload profile procedure is a multidimensional procedure with the unique ability to offer diagnostic information concerning the demand of the tasks. Both the Bedford and workload profile procedures use the absolute approach but the psychophysical procedure uses the relative approach. Lastly, the Bedford procedure asks for the rating immediately after performing each task; the other two procedures use a retrospective approach. The three assessment approaches were examined along four dimensions: sensitivity to manipulation of task demands, concurrent validity with task performance, test-retest reliability, and diagnosticity.
Author (Herner)

A95-95177
PERFORMANCE ASSESSMENT AND WORKOAD EVALUATION SYSTEM (PAWES): A PROCESS AND TOOL TO EVALUATE COCKPIT DESIGN DURING FLIGHT TEST
JULIE B. COHEN AL/CFA (CCCD) at Wright-Patterson AFB, OH, US, VALERIE J. GAWRON Arvin/Calspan Corp., Buffalo, NY, US, DEBORAH A. MUMMAW, and ARIC D. TURNER *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 871-876

A critical objective of flight testing piloted aircraft is to assess the operability of the crewstation and the adequacy of its design in terms of the aircrew's ability to meet mission objectives. Currently, there is no standard process for this important aspect of flight test. This has led to a variety of metrics and procedures being employed resulting in a lack of commonality in crewstation testing among test beds, programs and systems. Data from one flight test are often not comparable to those of another, leading to duplication of effort and a lack of efficiency in evaluations. The Performance Assessment and Workload Evaluation System (PAWES) will provide a structure and tools to improve future crewstation evaluations. Author (Herner)

A95-95178
DEVELOPMENT OF ELECTROPHYSIOLOGICAL MEASURES OF GA PILOT WORKLOAD
RUTH M. HERON Transportation Development Center, Montreal, Quebec, Canada, J. V. SVOBODA Concordia Univ., Montreal, Quebec, Canada, and H. WEINBERG Simon Fraser Univ., Burnaby, BC, Canada *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 877-881
Research sponsored by the Transportation Development Center, Concordia Univ., and Simon Frser Univ.

The aim of this preliminary two-study project is to establish experiental approaches to the subject, particularly regarding use of a microprocessor-based flight simulator along with electrophysiological (EEG) techniques for measuring workload. Study I, now to be reported, is preparatory to Study II and focusses largely on the latter area. The investigation is designed around the interest in the relationship between workload of general aviation (GA) pilots and global positioning system (GPS)-defined approach complexity. As the study is still in progress, the paper confines itself to apprising the reader

of the nature and direction of the research. Details of the design are provided, along with an explanation of how results might be applied to subsequent study. Author (revised by Herner)

A95-95179
THE EFFECT OF PREVIOUS LEVEL OF WORKLOAD ON THE NASA TASK LOAD INDEX (TLX) IN A SIMULATED FLIGHT TASK
WILLIAM F. MORONEY Univ. of Dayton, Dayton, OH, US, JACK REISING Univ. of Dayton, Dayton, OH, US, DAVID W. BIERS Univ. of Dayton, Dayton, OH, US, and F. THOMAS EGGEMEIER Univ. of Dayton, Dayton, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 882-885

Previous research with the task load index (TLX) has demonstrated its sensitivity to variations in workload within flight and other complex work conditions, but has not addressed some important methodological issues regarding its application. One of these areas is the effect of previous workload on the level of workload reported on subsequent tasks. This experiment attempted to create a situation in which subjects flew from a context of low medium or high workload levels to a medium level of workload. Analyses of the TLX data revealed significant reported workload differences between the low/medium and the high crosswind level conditions on the three context building trials but no differences among the TLX ratings reported under the medium level condition which followed. These findings lead us to conclude that, under the conditions examined in this experiment, TLX ratings are independent of the level of workload reported on previous trials. However, we feel that because of the design used: (1) Subjects may have compartmentalized the trials such that the context effect was inhibited and/or (2) The duration of the context trials may not have been sufficient to establish a context effect. Author (revised by Herner)

A95-95182
AN EXAMINATION OF A SUBJECTIVE SITUATIONAL AWARENESS MEASURE DURING TRAINING ON A TACTICAL OPERATIONS SIMULATOR
MARK S. CRABTREE Logicon Technical Services, Inc., Dayton, OH, US, RAYMUNDO A. Q. MARCELO Logicon Technical Services, Inc., Dayton, OH, US, ANNETTE L. MCCOY Logicon Technical Services, Inc., Dayton, OH, US, and MICHAEL A. VIDULICH Amstrong Lab. at Wright-Patterson AFB, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 891-895

Situational awareness (SA) refers to the pilot's ability to acquire information about the aircraft and the flight environment, process the information, and respond appropriately in real-time. The study described in this paper utilized the Simulator for Tactical Operations and Research measurement (STORM) facility for determing the sensitivity of the Situation Awareness Rating Technique (SART) to variables that might affect subjects' SA. Scientists at the Armstrong Laboratory developed STORM as a flexible tool for investigating SA issues in a simulate operational close air support/battlefield air interdiction (CAS/BAI) environment. Because visual displays are so important to pilots, the type of outside-the-cockpit display was chosen as the main variable to examine. Other variables included in the study were the presence/absence of enemy surface-to-air missile (SAM) systems, size of the target's vulnerable area, and approach scenario. Besides assessing SART's sensitivity to these variables, the study also examined changes in SA as subjects gained experience flying CAS/AI missions. Author (revised by Herner)

A95-95183
DEVELOPING SUBJECTIVE AND OBJECTIVE METRICS OF PILOT SITUATION AWARENESS
MICHAEL A. VIDULICH Amstrong Lab. at Wright-Patterson AFB, OH, US, MARK S. CRABTREE Logicon Technical Services, Inc., Dayton, OH, US, and ANNETTE L. MCCOY Logicon Technical Services, Inc., Dayton, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 896-900

The study undertook to compare situation awareness (SA) assessment techniques. The guiding logic was identical to those early mental workload studies. Laboratory tasks were developed to inflict different levels of SA in subjects performing a simulated air-to-ground attack. Several proposed SA measurement tools were used during the study. The construct validity of the measures were assessed by their sensitivity to the experimental manipulations and their reliability was assessed by calculating test-retest correlations. Author (Herner)

A95-95185
SITUATION AWARENESS AND WORKLOAD FLIP SIDES OF THE SAME COIN
MICA R. ENDSLEY Texas Tech Univ., Lubbock, TX, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 906-911

Mental workload in aircraft systems has been a topic of major concern for many years. Rather similarly, research on situation awareness (SA) has followed a parallel path. It is only natural then that many people have expressed an interest in how these two constructs relate to each other. To investigate this, a study was undertaken in which SA and workload were both measured in a flight scenario. SA and independent constructs. Author (revised by Herner)

A95-95186
COCKPIT ATTENTION AND TASK MANAGEMENT: SITUATION AWARENESS IN THE TACTICAL FIGHTER
BILL GORDON Hernandez Engineering, Inc., Denver, CO, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 912-917

Attention Management deals with the fighter pilot's and Weapons System Officer's perspective of situation awareness, a uniquely different outlook from that of the bomber, tanker, or transport crew. Situation awareness becomes even more difficult to define, much less establish and maintain, in many fighter scenarios. Task Management addresses the problems of task saturation and stress. Flight/Element Management treats the subjects of leadership, decision making, team building, and problem solving from the aspect of lead or wing positions, which includes significant variance from the problems encountered in single aircraft operations. Author (revised by Herner)

A95-95187
RELIABILITY AND VALIDITY ASSESSMENTS OF TASK ANALYSES USING MILLER'S TERMINOLOGY
GERALD P. CHUBB Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 918-923

Robert B. Miller proposed a list of 25 terms as his Task Strategies approach to task analysis. Proposed terms are behaviorally specific, abstract, verbal descriptions of human activities that might occur in many different operating contexts. The study examined the interpretation and application of Miller's terminology when used by relatively naive (first-time) analysts. The specific context for their task analysis was the arrival control aspect of a simulation game called TRACON II, which mimics aircraft Terminal Radar Approach Control (TRACON) operations at airports in the Los Angeles area (as the default traffic area for this software package). Author (revised by Herner)

A95-95188
MEASUREMENT OF FLIGHT CREW PERFORMANCE FOR THE ADVANCED QUALIFICATION PROGRAM
GEORGE L. KAEMPF Klein Associates Inc., Fairborn, OH, US and DAVID W. KLINGER Klein Associates Inc., Fairborn, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 924-929

The Advanced Qualification Program (AQP) allows air carriers to restructure the way that they train flight crews and the way that they develop training programs. The heart of AQP is proficiency-based training. Progression through an AQP curriculum depends on the student's ability to meet certain performance standards. That is, student progression is based on the student's ability to demonstrate proficiency relative to specific performance standards. Thus, valid and reliable performance measurement is a critical component of any training program implemented under AQP. The first objective of this project was to identify the elements of performance that experienced check airmen consider when they evaluate the performance of individual pilots and crews, including both technical and crew resource management components. The second objective was to incorporate these performance elements into a prototype performance measurement instrument (PMI) that would enable instructors to document and assess aviator and flight crew proficiency within the context of specific tasks and conditions. Author (revised by Herner)

A95-95189
THE DEVELOPMENT OF A 'QUALITY' MEASURE OF PILOT PERFORMANCE
HEATHER M. MCINTYRE Hughes Rediffusion Simulation Ltd, Crawley, Sussex, UK *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 930-933

In pilot training, the traditional measure of effectiveness takes the form of 'expert' subjective ratings of performance, made by an instructor. A more complete picture could perhaps be obtained if information from a number of parameters were to be integrated to give a multi-dimensional performance evaluation. The aim of the underlying models may be to obtain the same 'overall' assesments from quantitative simulator measures as would be given by an instructor observing the same performance. We would like to utilize this approach to derive a multi-dimensional measure, which will give some indication of the smoothness of the pilot's handling of the aircraft, as well as the acuracy of performance. The former has previously been considered to lie wholly within the subjective domain; as a qualitative judgment, undertaken by human observers, when assessing anticipation and consistency of performance. Our intention is to address the question of how such qualitative information can be represented in a quantitative model, preferably so as to be included in an automated data collection procedure, along with other parameter measurements. Author (revised by Herner)

A95-95190
A TOOL FOR EVALUATING STUDENT-PILOT PERFORMANCE DURING INSTRUMENT FLIGHT TRAINING
STEVEN HAMPTON Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, WILLIAM F. MORONEY Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, TOM KIRTON Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, and DAVID W. BIERS Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 934-938

The authors investigated the transfer effectiveness of selected personal computer (PC)-based training devices. An experiment is currently underway to compare the training effectiveness of three devices: a Federal Aviation Administration (FAA) approved trainer and two PC-based representative commercially available software packages. Because objective measures could not be obtained during the initial effort, the development of appropriate subjective measurements were crucial to the success of this effort. This paper describes the evolution of the performance evaluation form. Author (Herner)

A95-95191 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLIGHT PERFORMANCE MEASUREMENT UTILIZING A FIGURE OF MERIT (FOM)
KATHLEEN L. MOSIER Stanford Univ., Palo Alto, CA, US and GREG L. ZACHARIAS Charles River Analytics Inc., Cambridge, MA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 939-944

One of the goals of the NASA Strategic Behavior/Workload Management Program is to develop standardized procedures for constructing figures of merit (FOMs) that describe minimal criteria for flight task performance, as well as summarize overall performance quality. Such a measure could be utilized for evaluating flight crew performance, for assessing the effectiveness of new equipment or technological innovations, or for measuring performance at a particular airport. In this report, we describe the initial phases in the creation of a FOM to be employed in examining crew performance in NASA-Ames Air Ground Compatibility and Strategic Behavior/workload Management programs. Author (Herner)

A95-95195* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WORKLOAD MANAGEMENT AND GEOGRAPHIC DISORIENTATION IN AVIATION INCIDENTS: A REVIEW OF THE ASRS DATA BASE
HENRY P. WILLIAMS Univ. of Illinois at Urbana-Champaign, Urbana, IL, US, MINGPO THAM Univ. of Illinois at Urbana-Champaign, Urbana, IL, US, and CHRISTOPHER D. WICKENS Univ. of Illinois at Urbana-Champaign, Urbana, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 960-964
(Contract(s)/Grant(s): NAG2-308)

NASA's Aviation Safety Reporting System (ASRS) incident reports are reviewed in two related areas: pilots' failures to appropriately manage tasks, and breakdowns in geographic orientation. Examination of 51 relevant reports on task management breakdowns revealed that altitude busts and inappropriate runway usee were the most frequently reported consequences. Task management breakdowns appeared to occur at all levels of expertise, and prominent causal factors were related to breakdowns in crew communications, over-involvement with the flight management system and, for small (general aviation) aircraft, preoccupation with weather. Analysis of the 83 cases of geographic disorientation suggested that these too occurred at all levels of pilot experience. With regard to causal factors, a majority was related to poor cockpit resource management, in which inattention led to a loss of geographic awareness. Other leading causes were related to poor weather and poor decision making. The potential of the ASRS database for contributing to research and design issues is addressed. Author (Herner)

A95-95196
COCKPIT TASK MANAGEMENT ERRORS IN A SIMULATED FLIGHT OPERATION
CHUNG-DI CHOU Quantum Software, Claymont, DE, US and KEN FUNK Oregon State Univ., Corvallis, OR, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 965-969

The general objective of our research has been to determine the significance of cockpit task management (CTM) to aviation

safety and to determine if safety can be improved through the improvement of CTM behavior. This paper describes a study of CTM errors contributing to air accidents and incidents and a laboratory study of CTM behavior. The organization of the paper is as follows. The first section presents an error taxonomy for classifying CTM errors. The following section presents findings from a study of CTM errors contributing to aircraft accidents. Then we describe a laboratory study of CTM errors. Finally, we conclude the paper with some design guidelines for improved, task-oriented pilot-vehicle interfaces to facilitate CTM performance. Author (revised by Herner)

A95-95197
COCKPIT TASK MANAGEMENT ERRORS IN CRITICAL IN-FLIGHT INCIDENTS
DAS MADHAVAN Oregon State Univ., Corvallis, OR, US and KEN FUNK Oregon State Univ., Corvallis, OR, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 970-974

The purpose of this study is to apply the cockpit task management (CTM) error taxonomy to a larger collection of Aviation Safety Reporting System (ASRS) incident reports in order to increase the body of evidence concerning the significance of CTM to aviation safety. Towards these ends we have two subgoals. The first is to refine the error taxonomy and validate it with a small set of incident reports. The second is to apply the refined taxonomy in a formal study of a larger collection of incident reports. Author (Herner)

A95-95200
MAIL PILOTS AND MISCHIEF: MEETING GOALS AND VIOLATING RULES
SIDNEY W. A. DEKKER Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 985-989

Non-adherence to rules, regulations and procedures in cockpits has hardly been looked at as a phenomenon in its own right. In this study, pilots dealings with rules in day to day operations were observed on 38 domestic flights in New Zealand. It was concluded that pilots adapt rules in a locally pragmatic way, constrained as they sometimes are by the multiple interacting and seemingly irreconcilable goals of their operations. These adaptations range from effective to brittle to ineffective in terms of how far pilots keep the system away from possible concatenation with local factors that together may cause system breakdown. Operations that are 'violation breeding grounds shoud not first be scrutinized for occurring violations, but instead for the multiple goals that pilots are supposed to meet in those operations. Author (Herner)

A95-95202* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DATA LINK AIR TRAFFIC CONTROL AND FLIGHT DECK ENVIRONMENTS: EXPERIMENT IN FLIGHT CREW PERFORMANCE
SANDY LOZITO San Jose State Univ., San Jose, CA, US, ALISON MCGANN Sterling Software, US, and KEVIN CORKER NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1009-1015

This report describes an experiment undertaken in a full mission simulation environment to investigate the performance impact of, and human/system response to, data-linked Air Traffic Control (ATC) and automated flight deck operations. Subjects were twenty pilots (ten crews) from a major United States air carrier. Crews flew the Advanced Concepts Flight Simulator (ACFS), a generic 'glass cockpit' simulator at NASA Ames. The method of data link used was similar to the data link implementation plans for a next-generation aircraft, and included the capability to review ATC messages and directly enter ATC clearance information into the aircraft systems. Each crew flew experimental scenarios, in which data reflecting communication timing, errors and clarifications, and procedures were collected. Results for errors and clarifications revealed an interaction between communication modality (voice v. data link) and communication type (air/ground v. intracrew). Results also revealed that voice crews initiated ATC contact significantly more than data link crews. It was also found that data link crews performed significantly more extraneous activities during the communication task than voice crews. Descriptive data from the use of the review menu indicate the pilot-not-flying accessing the review menu most often, and also suggest diffulty in accessing the target message within the review menu structure. The overall impact of communication modality upon air/ground communication and crew procedures is discussed. Author (Herner)

A95-95206
ASRS AND AVIATION PSYCHOLOGY
CHRISTOPHER D. WICKENS Aviation Research Lab., Savoy, IL, US and THOMAS M. MCCLOY FAA, Washington, DC, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1028-1030

Incident reports such as those contained within the Aviation Safety Reporting System (ASRS) provide a vital link between mishaps reports, that possess high fidelity but low numbers and ambiguous causality and laboratory or simulator-based experiments that are lower fidelity, but allow more reliable causal attribution. Current limitations of ASRS relate to its coding of psychological causes, its statistical biases, and its integration with other data bases. Author (Herner)

A95-95208
PATHFINDER ANALYSIS OF MILLER'S TASK ANALYSIS TERMINOLOGY
TAMMY R. BROWN Ohio State Univ., Columbus, OH, US and GERALD P. CHUBB Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1039-1044

This study examined the use of Miller's task analysis terminology in the context of Terminal Radar Approach Control (TRACON). Participants first learned to operate the Tracon II game software. Then they were asked to do a task analysis. In conjunction with task analysis assignment, a 300 item questionnaire (paired comparison rating scales) was administered. Author (Herner)

A95-95209
THE EFFECTS OF BOREDOM ON REACTION TIME IN THE COCKPIT
RICK BUTCHER Ohio State Univ., Columbus, OH, US, MATT GRASHEL Ohio State Univ., Columbus, OH, US, and TRICIA LUGAILA Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1045-1048

The evolution of modern transport airplanes has altered the role of pilots. Some modern airplanes are highly automated, and no longer require continuous attention from the pilots. Duties that at one time kept pilots busy are now automatic functions of the airplanes. One of the costs of increasing automation may be boredom in the cockpit. This boredom may increase the reaction time of pilots, especially if the pilots are presented with incorrect information. In order to demonstrate this effect, a flight simulator was used to time the reactions of pilots under two scenarios. In one group, pilots were continuously challenged throughout a flight and in the other group pilots were allowed to become complacent during a boring flight. At

the end of each flight, the time to react to false information was recorded. The goal was to find a noticeable difference in the reaction times of each group. Author (Herner)

A95-95615
PSYCHOPHYSIOLOGICAL PARAMETERS OF OPERATORS WITH DIFFERENT LEVELS OF ANXIETY DURING ACTIVITY UNDER MOTIVE COMPETITION
O. O. RYUMIN Russian Academy of Sciences, Moscow, Russia, V. V. MORGUN Russian Academy of Sciences, Moscow, Russia, M. L. KHACHATURYANZ Russian Academy of Sciences, Moscow, Russia, and N. D. SOROKINA Russian Academy of Sciences, Moscow, Russia Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 1-6
(HTN-95-93114) Copyright

The paper studied and discussed the effect of pilots' anxiety levels on psychophysiological parameters in simulated conditions. It was suggested that the priority might be given to individuals with low anxiety when selecting operators for work in conflict situations and that the priority is given to individuals with the same anxiety levels when carrying out joint activity by small groups.
Author (Herner)

N95-30905# Armstrong Lab., Brooks AFB, TX. Aerospace Medicine Directorate.
USING COMPUTERIZED NEUROPSYCHOLOGICAL TESTING TO ASSESS AVIATOR SKILLS Final Technical Report
CHRISTOPHER F. FLYNN and RAYMOND B. KING Dec. 1994 21 p
(Contract(s)/Grant(s): AF PROJ. 7755; AF PROJ. ILIR)
(AD-A293227; AL/AO-TR-1994-0174) Avail: CASI HC A03/MF A01

Successful pilots must be cognitively and psychologically 'fit' to preserve cockpit situational awareness while executing complex job demands in an unforgiving environment. The neuropsychological attributes of successful U.S. Air Force (USAF) aircrew, however, are largely unstudied. To conveniently collect a large sample of aviators data for comparison to mission performance, an easy-to-use and reliable test delivery system is required. The Neuropsychiatrically Enhanced Flight Screening (N-EFS) program is one product of an effort by Armstrong Laboratory's (AL) Neuropsychiatry Branch (AOCN). N-EFS measures the cognitive functioning (using the Multidimensional Aptitude Battery, MAB; and CogScreen) and psychological attributes and crew resource management potential (using the Personal Characteristics Inventory PCI; and the Revised NEO-Personality Inventory, NEO-PI-R) of all USAF pilot candidates. This data will establish a range of cognitive attributes of pilot applicants, and will provide MAB CogScreen baseline data for future reference. The N-EFS program also seeks to validate the MAB, CogScreen, NEO-PI-R. and PCI as future tools for pilot selection and understanding situational awareness. N-EFS builds on earlier AL/AOCN efforts to develop a 'field-friendly,' self-administered, computerized psychometric testing battery to define attributes of successful pilots. DTIC

N95-31140# Army Aeromedical Research Lab., Fort Rucker, AL.
LUMINANCE EFFECTS ON VISUAL ACUITY AND SMALL LETTER CONTRAST SENSITIVITY Final Report
JEFF RABIN Feb. 1995 15 p
(AD-A293310; USAARL-95-14) Avail: CASI HC A03/MF A01

The purpose of this study was to evaluate the effects of luminance on visual acuity (VA) and small letter contrast sensitivity (SLCS). Computer-generated letter charts were used to measure VA and SLCS (6/7.5 (20/25) Snellen equivalent) as a function of stimulus luminance. Letter size (VA) and contrast (SLCS) were varied in equal logarithmic steps, making the task and scoring procedure comparable for the two types of measurement. Both VA and SLCS decreased with decreasing luminance, but the effect was far greater in the contrast domain. Reducing luminance from 116 cd/m2 to 0.23 cd/sq m produced a 3 x reduction in VA, but a 17 x reduction in SLCS. The greater sensitivity of SLCS to luminance endured even after correction for greater measurement variability. SLCS is a sensitive approach for detecting resolution loss undisclosed by standard measures of VA. It may be useful for monitoring visual loss from light attenuation in early cataracts, and for detecting subtle resolution loss from neural or pathologic factors in ocular and neuroophthalmologic disease. DTIC

N95-31376# Armstrong Lab., Brooks AFB, TX. Aerospace Medicine Directorate.
PSYCHOLOGICAL PILOT SELECTION IN THE US AIR FORCE, THE LUFTWAFFE, AND THE GERMAN AEROSPACE RESEARCH ESTABLISHMENT Final Technical Report
MONIKA GNAN, CHRISTOPHER F. FLYNN, and RAYMOND E. KING Feb. 1995 33 p
(AD-A293779; AL/AO-TR-1995-0003) Avail: CASI HC A03/MF A01

As financial resources for the U.S. Air Force (USAF) and the German Luftwaffe (LW) dwindle, reducing attrition from military aviation training becomes vital. Finding the optimal mixture of applicant personality, stamina, and psychomotor skills for aviation is a goal as complicated as it is elusive. This paper compares the USAF, LW and German Aerospace Research Establishment (DLR) pilot selection programs. The LW and DLR utilize a sequential psychological selection system including apparatus tests, psychological interviews and behavioral observations, while in the USAF psychological selection does not play an important role. Instead, medical standards, flight screening, and training attrition are used as USAF selection criteria. However, a new USAF program, Neuropsychiatrically Enhanced Flight Screening (N-EFS) will examine the personality characteristics of pilot applicants for further study. The USAF and LW could learn from the strengths and weaknesses of their respective selection programs. The opportunity for cooperative research is even greater, considering that the USAF and LW pilot students share common jet pilot training. DTIC

N95-31383# Carnegie-Mellon Univ., Pittsburgh, PA. School of Computer Science.
VISUAL TRACKING OF SELF-OCCLUDING ARTICULATED OBJECTS
JAMES R. REHG and TAKEO KANADE 31 Dec. 1994 42 p Presented at the International Conference on Computer Vision, Boston, MA, Jun. 1995 Sponsored in part by NASA George Marshall Space Flight Center
(Contract(s)/Grant(s): NGT-50559)
(AD-A292894; CMU-CS-94-224) Avail: CASI HC A03/MF A01

Computer sensing of hand and limb motion is an important problem for applications in human-computer interaction, virtual reality, and athletic performance measurement. We describe a framework for local tracking of self-occluding motion, in which parts of the mechanism obstruct each others visibility to the camera. Our approach uses a kinematic model to predict occlusion and windowed templates to track partially occluded objects. We analyze our model of self-occlusion, discuss the implementation of our algorithm, and give experimental results for 3D hand tracking under significant amounts of self-occlusion. These results extend the DigitEyes system for articulated tracking described in 22, 21 to handle self-occluding motions. DTIC

N95-31436# Smith-Kettlewell Inst. of Visual Sciences, San Francisco, CA.
VISUAL PROCESSING OF OBJECT VELOCITY AND ACCELERATION Final Technical Report, 15 Jan. 1992 - 14 Jan. 1995
SUZANNE MCKEE 6 Mar. 1995 17 p
(Contract(s)/Grant(s): F49620-92-J-0156)
(AD-A292789; AFOSR-95-0243TR) Avail: CASI HC A03/MF A01

The main objective of this project was the analysis of the detection of trajectory signals in random motion noise. Results from experiments demonstrated that detection was limited by the probability of mismatch, not noise density per se; detection was based on a motion signal, not a form or position signal; detection was limited

by higher-order aspects of motion processing, not the ratio of signal to noise in the primary motion detectors. The Yuille-Grzywacz 'Motion Coherence' model was modified to provide a computational model for these findings. Computer simulations showed that this model was adequate to reproduce our results. In addition, three other projects were supported by this grant: motion transparency from speed signals alone; speed discrimination for targets moving in depth; trajectory motion detection in three-dimensional noise. Nine papers from this project have been accepted in referred journals; one additional paper has been submitted. Four chapters were also supported by this grant. DTIC

N95-31583# Galaxy Scientific Corp., Lackland AFB, TX.
CONTEXTUAL INTERFERENCE EFFECTS ON ACQUISITION AND TRANSFER OF A COMPLEX MOTOR TASK Interim Report, Oct. 1993 - Mar. 1994
BARRY P. GOETTL Feb. 1995 15 p
(Contract(s)/Grant(s): F41622-92-D-0006)
(AD-A293788; AL/HR-TP-1994-0034) Avail: CASI HC A03/MF A01

Research in motor skill and verbal memory suggests that random sequencing of trials results in retention and transfer that is superior to blocked presentation of trials. The contextual interference effect is based largely on relatively simple motor and verbal tasks. The present study explores the generalizability of the contextual interference effect to a complex flight simulator task. Subjects were assigned to three groups: whole-task training, low contextual interference, and high contextual interference. Results indicated that whole task subjects showed the best retention and that the two contextual interference groups did not differ. Additionally, all three groups showed equivalent performance on the transfer task. These results suggest that the contextual interference effect may not generalize to complex tasks. DTIC

N95-31585# Colorado Univ., Boulder, CO.
OPTIMIZING THE LONG-TERM RETENTION OF SKILLS: STRUCTURAL AND ANALYTIC APPROACHES TO SKILL MAINTENANCE Final Report, May 1990 - Oct. 1993
ALICE F. HEALEY Jan. 1995 46 p
(Contract(s)/Grant(s): MDA903-90-K-0066; DA PROJ. 201-61102-B-74-F)
(AD-A293798; ARI-RN-95-16) Avail: CASI HC A03/MF A01

Progress has been made in determining guidelines for optimizing the long-term retention of skills. Studies on learning and retention of color-word interference, schedule components, list components, mental arithmetic, and vocabulary acquisition suggest that optimal retention will result from using procedures during training, relating information to previous experience, making the information distinctive, promoting direct retrieval of the information, and providing refresher or practice tests. DTIC

N95-31685# Carnegie-Mellon Univ., Pittsburgh, PA. Robotics Inst.
FORCE AND VISION RESOLVABILITY FOR ASSIMILATING DISPARATE SENSORY FEEDBACK
BRADLEY J. NELSON and PRADEEP K. KHOSLA Feb. 1995 48 p
(Contract(s)/Grant(s): DAAL03-91-G-0272)
(AD-A293581; CMU-RI-TR-95-11) Avail: CASI HC A03/MF A01

Force and vision sensors provide complementary information, yet they are fundamentally different sensing modalities. This implies that traditional sensor integration techniques that require common data representations are not appropriate for combining the feedback from these two disparate sensor. In this paper, we introduce the concept of vision and force sensor resolvability as a means of comparing the ability of the two sensing modes to provide useful information during robotic manipulation tasks. By monitoring the resolvability of the two sensing modes with respect to the task, the information provided by the disparate sensors can be seamlessly assimilated during task execution. A nonlinear force/vision serving algorithm that uses force and vision resolvability to switch between sensing modes is proposed. The advantages of the assimilation technique is demonstrated during contact transitions between a stiff manipulator and rigid environment, a system configuration that easily becomes unstable when force control alone is used. Experimental results show that robust contact transitions are made by the proposed nonlinear controller while simultaneously satisfying the conflicting task requirements of fast approach velocities, maintaining stability, minimizing impact forces, and suppressing bounce between contact surfaces. DTIC

N95-31686# California Univ., Los Angeles, CA. Dept. of Psychology.
A COGNITIVE ARCHITECTURE FOR SOLVING ILL-DEFINED PROBLEMS Interim Report, Sep. 1986 - Aug. 1987
KEITH J. HOLYOAK and PAUL R. THAGARD (Princeton Univ., NJ.)
Feb. 1995 59 p
(Contract(s)/Grant(s): MDA903-86-K-0297)
(AD-A293582; ARI-RN-95-24) Avail: CASI HC A04/MF A01

A computational theory of analogical mapping is described, based on a small set of constraints. The theory is embodied in a computer simulation that is applied to several examples, including psychological data on the mapping process. DTIC

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MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering; biotechnology; and space suits and protective clothing.

A95-93614
AIRCREW ACCEPTANCE OF AUTOMATION IN THE COCKPIT
I. F. ROSS and M. R. HICKS 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 30: Avionic Systems)
(CONGRESS PAPER C428-30-179; HTN-95-21183) Copyright

The concept of human-electronic co-operation in the cockpit is synonymous with that of a team. Whether or not team members interact effectively will rely largely upon the pilot's acceptance of his electronic team mate. This paper reports on the attitudes of eight British Aerospace test pilots towards the future of such co-operation. Particular emphasis is laid upon the factors of system function, task allocation and trust. Pilots opinions are examined against a schema of operational relationships, recently proposed in the literature.
Author (Herner)

A95-93762
PREPARATIONS FOR CELSS FLIGHT EXPERIMENTS WITH WHEAT
F. SALISBURY Utah State University, Logan, Utah, US, L. GILLESPIE Utah State University, Logan, Utah, US, and G. BINGHAM Utah State University, Logan, Utah, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)21-(11)27
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We are planning a short-term experiment with Superdwarf wheat on the U.S. Space Shuttle and a seed-to-seed experiment on the Russian Space Station Mir. The goals of both experiments are to observe effects of microgravity on developmental steps in the life cycle and to measure photosynthesis, respiration, and transpiration by monitoring gas exchange. This requires somewhat different hardware devlopment for the two experiments. Ground-based research aims to understand plant responses to the environments in the space growth chambers that we will use (after some modification): Plant Growth Unit (PGU) on the shuttle and units called Svet, Svetoblock 2, or Oasis on Mir. Low irradiance levels (100 to 250 micromol/sq m/s at best) pose a particular problem. Water and

nutrient supply are also potentially limiting factors, especially in the long term experiment. Our ground-based studies emphasisze responses to low light levels (50 to 400 micormol/sq m/s); results show that all developmental steps are delayed by low light compared with plants at 400 micromol/sq m/s. We are also testing various rooting substances for the shuttle experiment. A 1:1:1 mixture of peat:perlite:vermiculite appears to be the best choice.

Author (revised by Herner)

A95-93767 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS) FLIGHT EXPERIMENTATION

M. KLISS GE Government Services, Moffett Field, California, US, R. MACELROY GE Government Services, Moffett Field, California, US, B. BORCHERS GE Government Services, Moffett Field, California, US, M. FARRANCE GE Government Services, Moffett Field, California, US, T. NELSON GE Government Services, Moffett Field, California, US, C. BLACKWELL GE Government Services, Moffett Field, California, US, B. YENDLER GE Government Services, Moffett Field, California, US, and J. TREMOR GE Government Services, Moffett Field, California, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)61-(11)69

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The NASA CELSS program has the goal of developing life support systems for humans in space based on the use of higher plants. The program has supported research at universities with a primary focus of increasing the productivity of candidate crops plants. To understand the effects of the space environment on plant productivity, the CELSS Test Facility (CTF) has been conceived as an instrument that will permit the evaluation of plant productivity on Space Station Freedom. The CTF will maintain specific environmental conditions and collect data on gas exchange rates and biomass accumulation over the growth period of several crop plants grown sequentially from seed to harvest. The science requirements for the CTF will be described, as will current design concepts and specific technology requirements for operation in micro-gravity.

Author (revised by Herner)

A95-93768

BIOLOGICAL LIFE SUPPORT FOR MANNED MISSIONS BY ESA

R. A. BINOT European Space Agency, Noordwijk, The Netherlands, C. TAMPONNET European Space Agency, Noordwijk, The Netherlands, and CH. LASSEUR European Space Agency, Noordwijk, The Netherlands Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)71-(11)74

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The anticipated evolution of life support technologies for ESA, considering both the complementary life support system requirements and the missions' characteristics, is presented. Based on these results, promising biological life support technologies for manned space missions have been selected by ESA either for their intrinsic ability and performance in effecting specific tasks for atmosphere-, water-, waste-management versus physico-chemical alternatives and/or longer-term application to a more ecological concept (CES) focusing ultimately on food production. Actual status and plan for terrestrial and space testing of biological life support systems are presented focusing on the 'task specific' decontamination technology of the Biological Air Filter (BAF), and on food reprocessing technologies from biodegradable wastes with the MELISSA microbial ecosystem. Author (revised by Herner)

A95-93769

DEVELOPMENT OF A CELSS BIOREACTOR: OXYGEN TRANSFER AND MICROMIXING IN PARABOLIC FLIGHT

P. E. VILLENEUVE Colorado State University, Fort Collins, Colorado, US, K. S. WENGER Colorado State University, Fort Collins, Colorado, US, B. G. THOMPSON Alberta Research Council, Edmonton, Alberta, Canada, T. KEDAR Strathclyde University, Glasgow, Scotland, and E. H. DUNLOP Colorado State University, Fort Collins, Colorado, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)75-(11)78

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The gas exchange portion of a phase-separated loop bioreactor was tested with respect to oxygen mass transfer and micromixing in accelerations of 0.01g, 1g, and 2g. A plot of the overall mass transfer coefficient versus gravity indicates the rate of oxygen transfer does not change as a function of acceleration. Also, it was determined that the mircomixing did not exhibit significant changes in the various gravitational fields. These observations indicate the loop bioreactor should function independent of acceleration.

Author (revised by Herner)

A95-93770

'SYMBIOSE' SYSTEM FOR MICROGRAVITY BIOREGENERATIVE SUPPORT OF EXPERIMENTS

F. BRECHIGNAC European Space Agency, Noordwijk, The Netherlands and L. WOLF European Space Agency, Noordwijk, The Netherlands Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)79-(11)88

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SYMBIOSE is an ESA supported research and development program which aims at establishing a first pilot model of a closed ecological system, compatible with operation in weightlessness conditions, and dedicated to scientific investigations in the microgravity environment. It integrates microalgal photosynthesis within an artificial ecosystem featuring a symbiotic strain of Chlorella (241.80 Goettingen), which synthesizes and excretes substantial amounts of maltose, and is further looped on a consumer compartment. A technological concept has been developed. It is presently being integrated in order to gain knowledge on the system dynamics, and ultimately demonstrate the feasibility of such a biotechnology. Preliminary work on the photosynthetic metabolism of this microalga is being undertaken in order (1) to support later a mathematical formalization of the dynamics of this artificial ecosystem, and, on this basis, (2) to compensate for its lack of stability with model-based external control. The most recent results are presented, along with a new design of the photobioreactor which integrates efficient light energy capture, microgravity compatible gas transfer and reduced shear stress. Author (revised by Herner)

A95-93772

TOLUENE REMOVAL FROM AIR BY DIEFFENBACHIA IN A CLOSED ENVIRONMENT

J. R. PORTER Philadelphia College of Pharmacy and Science, Philadelphia, Pennsylvania, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)99-(11)103

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Higher plants are likely to play a major role in bioregeneration systems for food, air and water supplies. Plants may also contribute by the removal of toxic organic substances from the air of a closed environment. Dieffenbachia amoena plants were exposed to 0 to 1.2 x 10(exp 6) microgram toulene/cu m at light intensities of 35 and 90 micromol/sq m/s in sealed chambers. Toulene removal, photsynthesis and respiration were measured. An increased light intensity increased the rate of toulene removal five-fold over the rate at the

lower intensity; the kinetics suggest active regulation by the plant. The removal rate saturated at 2700 microgram toulene/h at the lower intensity and failed to saturate at the higher intensity. Toulene exposure inhibited photosynthesis and respiration only transiently and without correlation to toluene concentration. These plants can act as efficient scavengers of toulene in a contaminated environment. Author (revised by Herner)

A95-93773
LUNAR BASE CELSS DESIGN AND ANALYSIS
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This paper describes the conceptual development of a hybrid biological-physical/chemical (P/C) life support system model for a lunar outpost. It presents steps that lead to loop closure and determines mass flow characteristics for an inedible biomass enzyme reactor and an activated sludge bioreactor. Computer modeling techniques were used to determine that the cellulose reactor has the design capabilities to provide significant increases in the plant harvest index. Activated sludge was found to fit design demands for a small, continuous-flow, steady-state system. Systems analysis and component sizing for these two bioreactors and information regarding supporting bioregenerative and physical/chemical components are presented. Author (revised by Herner)

A95-93774 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPROACHES TO RESOURCE RECOVERY IN CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS
D. L. BUBENHEIM NASA-Ames Research Center, Moffett Field, California, US and T. WYDEVEN NASA-Ames Research Center, Moffett Field, California, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)113-(11)123
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Recovery of resources from waste streams in a space habitat is essential to minimize the resupply burden and achieve self sufficiency. The ultimate goal of a Controlled Ecological Life Support System (CELSS) is to achieve the greatest practical level of mass recycle and provide self sufficiency and safety for humans. Several mission scenarios leading to the ultimate application could employ CELSS component technologies or subsystems with initial emphasis on recycle of the largest mass components of the waste stream. Candidate physical/chemical and biological processes for resource recovery from liquid and solid waste streams are discussed and the current fundamental recovery potentials are estimated.
Author (revised by Herner)

A95-93775
CELSS: POSSIBLE CONTRIBUTIONS TO EARTH SCIENCE PROGRAM AND OTHERS
K. NITTA National Aerospace Laboratory, Chofu, Tokyo, Japan and K. OHTSUBO National Aerospace Laboratory, Chofu, Tokyo, Japan Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)125-(11)134
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Controlled ecological life support systems (CELSS) technology, composed of various subsystems designed to stabilize the environment in closed space can be used to construct the Closed Ecology Experiment Facility. The Closed Ecology Experiment Facility has the character of an Environmental Time Machine. Many environmental studies will, it is proposed, be conducted using this facility. The concept of Closed Ecology Experiment Facility is described, and several potential research items related to earth science to be conducted using this facility are indicated. As an example of the application, an improved model of climate estimation is discussed. Author (revised by Herner)

A95-93776
INDICATIONS AND COUNTERINDICATIONS FOR APPLYING DIFFERENT VERSIONS OF CLOSED ECOSYSTEMS FOR SPACE AND TERRESTRIAL PROBLEMS OF LIFE SUPPORT
V. V. MEZHEVIKIN International Center for Closed Ecological Systems, Russia, V. A. OKHONIN International Center for Closed Ecological Systems, Russia, S. I. BARTSEV International Center for Closed Ecological Systems, Russia, and J. I. GITELSON International Center for Closed Ecological Systems, Russia Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)135-(11)142
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Different versions of manned closed ecosystems (CES) based on photosynthesis of unicellular and/or higher plants and chemosynthesis of bacteria are consdered. Different versions of CES have been compared for applying them on Earth, Moon, Mars and Venus orbital stations, for Mars missions and planetary stations as well as to provide high-quality life in extreme conditions on the Earth. In microgravity we recommend CES with unicellular organisms based on photosynthesis or chemosynthesis (depending on the availability of the light or electric energy). For the planetary stations with Moon gravity and higher, CES with higher plants are recommended. Improvement of indoor air quality by CES biotechnology is considered. Author (revised by Herner)

A95-93779
SPIRULINA ACCEPTABILITY TRIALS IN RATS. A STUDY FOR THE 'MELISSA' LIFE-SUPPORT SYSTEM
N. TRANQUILLE Gaubius Laboratory, Leiden, The Netherlands, J. J. EMEIS Gaubius Laboratory, Leiden, The Netherlands, D. DE CHAMBURE ESA-ESTEC, Noordwijk, The Netherlands, R. BINOT ESA-ESTEC, Noordwijk, The Netherlands, and C. TAMPONNET ESA-ESTEC, Noordwijk, The Netherlands Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)167-(11)170
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Groups of five rats were fed for sixteen weeks a slightly deficient diet, supplemented with 0-40% of a dried preparation of the blue-green alga Spirulina as a protein source. Control groups were fed a normal rat diet. No significant differences between groups were found in food intake, growth rate or carbon dioxide production. All animals remained apparently healthy, and had similar organ weights. The study suggests that Spirulina may be used as a protein source in rat diets. Author (revised by Herner)

A95-93797
NEUTRAL NETWORKS FOR CONTROL, IDENTIFICATION AND DIAGNOSIS
H. E. RAUCH Lockheed Palo Alto Research Laboratory, Palo Alto, California, US and D. B. SCHAECHTER Lockheed Palo Alto Research Laboratory, Palo Alto, California, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)297-(11)305

Advances in the theory and technology of artificial neural networks provide the potential for new approaches to the problems of control, identification, and diagnosis for large, complex systems. However, these approaches must be validated for specific applications before they can be exploited effectively. Because of the unique capabilities they offer, neural networks should play an important role in space exploration systems operations. After a brief introduction to neural networks is presented, some applications of neural networks to identification and control of space systems are described and discussed. They span the spectrum of realtively straightforward to rather complex applications. An explanation of how neural networks can be applied to such important tasks as fault diagnosis and accommodation is presented. Neural networks are shown to be part of the heirachy of intelligent control where a higher order decision element monitors and supervises lower order elements for sensing and actuation.

Author (revised by Herner)

A95-93798
QUALITATIVE REASONING METHODS FOR CELSS MODELING

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Qualitative Reasoning (QR) is a branch of Artificial Intelligence that arose from research on engineering problem solving. This paper describes the major QR methods and techniques, which, we believe, are capable of addressing some of the problems that are emphasized in the literature and posed by Controlled Ecological Life Support Systems (CELSS) modeling, simulation, and control at the supervisory level. Author (revised by Herner)

A95-93799 National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
OBJECT-ORIENTED MODEL-DRIVEN CONTROL

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A monitoring and control subsystem architecture has been developed that capitalizes on the use of model-driven monitoring and predictive control, knowledge-based data representation, and artificial reasoning in an operator support mode. We have developed an object-oriented model of a Controlled Ecological Life Support System (CELSS). The model based on the NASA Kennedy Space Center CELSS breadboard data, tracks carbon, hydrogen, and oxygen, carbodioxide, and water. It estimates and tracks resorce-related parameters such as mass, energy, and manpower measurements such as growing area required for balance. We are developing an interface with the breadboard systems that is compatible with artificial reasoning. Initial work is being done on use of expert systems and user interface development. This paper presents an approach to defining universally applicable CELSS monitor and control issues, and implementing appropriate monitor and control capability for a particular instance: the KSC CELSS Breadboard Facility. Author (revised by Herner)

A95-93801 National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
PERFORMANCE AND RELIABILITY OF THE NASA BIOMASS PRODUCTION CHAMBER

R. E. FORTSON J. F. Kennedy Space Center, Kennedy Space Ctr, Florida, US, J. C. SAGER NASA Biomedical Operations and Research Office, Kennedy Space Ctr, Florida,, and P. V. CHETIRKIN J. F. Kennedy Space Center, Kennedy Space Ctr, Florida, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)327-(11)330

The Biomass Production Chamber (BPC) at the Kennedy Space Center is part of the Controlled Ecological Life Support System (CELSS) Breadboard Project. Plants are grown in a closed environment in an effort to quantify their contributions to the requirements for life support. Performance of this system is described. Also, in building this system, data from component and subsystem failures are being recorded. These data are used to identify problem areas in the design and implementation. The techniques used to measure the reliability will be useful in the design and construction of future CELSS. Possible methods for determining the reliability of a green plant, the primary component of CELSS, are discussed.

Author (revised by Herner)

A95-93802
METHODS FOR MEASUREMENT AND CONTROL OF LEAKAGE IN CELSS AND THEIR APPLICATION AND PERFORMANCE IN THE BIOSPHERE 2 FACILITY

W. F. DEMPSTER Space Biospheres Ventures, Oracle, Arizona, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)331-(11)335

Atmospheric leakage between a Controlled Ecological Life Support System (CELSS) and its surround is driven by the differential pressure between the two. In an earth-based CELSS, both negative and positive differential pressures of atmosphere are created as the resultant of three influences: thermal expansion/contraction, transition of water between liquid and vapor phases, and external barometric pressure variations. The resultant may typically be on the order of 5000 pascals. By providing a flexible expansion chamber, the differential pressure range can be reduced two, or even three, orders of magnitude, which correspondingly reduces the leakage. The expansion chamber itself can also be used to measure the leak rate. Independent confirmation is possible by measurement of the progressive dilution of a trace gas. These methods as employed at the Biosphere 2 facility have resulted in an estimated atmospheric leak rate of less than 10 percent per year.

Author (revised by Herner)

A95-93808 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MICROBIOLOGICAL CHARACTERIZATION OF A REGENERATIVE LIFE SUPPORT SYSTEM

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(ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)377-(11)382

A Variable Pressure Plant Growth Chamber (VPGC), at the Johnson Space Center's (JSC) ground based Regenerative Life Support Systems (RLSS) test bed, was used to produce crops of soil-grown lettuce. The crops and chamber were analyzed for microbiological diversity during lettuce growth and after harvest. Bacterial counts for the rhizosphere, spent nutrient medium, heat exchanger condensate, and atmosphere were approximately 10(exp 11) Colony Forming Units (CFU)/g, 10(exp 5) CFU/ml, 10(exp 5)CFU/ml, and 600 CFU/m sq, repectively. Pseudomonas was the predominant bacterial genus. Numbers of fungi were about 10(exp 5) CFU/g in the rhizosphere, 4-200 CFU/ml in the spent nutient medium, 110 CFU/ml in the heat exchanger condensate, and 3 CFU/cu m in the atmosphere. Fusarium and Trichoderma were the predominant fungal genera. Author (revised by Herner)

A95-93812 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
REGENERATIVE LIFE SUPPORT SYSTEMS - WHY DO WE NEED THEM?
D. J. BARTA National Aeronautics and Space Administration, Houston, Texas, US and D. L. HENNINGER National Aeronautics and Space Administration, Houston, Texas, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)403-(11)410

Human exploration of the solar system will include missions lasting years at a time. Such missions mandate extensive regeneration of life support consumables with efficient utilization of local planetary resources. As missions durations extend beyond one or two years, regenerable human life support systems which supply food and recycle air, water, and wastes become feasible; resupply of large volumes and masses of food, water, and atmospheric gases become unrealistic. Additionally, reduced dependency on resupply or self sufficiency can be an added benefit to human crews in hostile environments far from the security of Earth. Comparisons of resupply and regeneration will be discussed along with possible scenarios for developing and implementing human life support systems on the Moon and Mars. Author (revised by Herner)

A95-93814
ATMOSPHERIC DYNAMICS AND BIOREGENERATIVE TECHNOLOGIES IN A SOIL-BASED ECOLOGICAL LIFE SUPPORT SYSTEM: INITIAL RESULTS FROM BIOSPHERE 2
M. NELSON Space Biospheres Ventures, Oracle, Arizona, US, W. DEMPSTER Space Biospheres Ventures, Oracle, Arizona, US, N. ALVAREZ-ROMO Space Biospheres Ventures, Oracle, Arizona, US, and T. MACCALLUM Space Biospheres Ventures, Oracle, Arizona, US Life sciences and space research 25 (3): Natural and artificial ecosystems; Meeting F4 of the COSPAR Plenary Meeting, 29th, Washington, DC, Aug. 28-Sep. 5, 1992. A95-93759 Advances in Space Research (ISSN 0273-1177) vol. 14, no. 11 November 1994 p. (11)417-(11)426

Biosphere 2 is the first man-made, soil-based, bioregenerative life suport system to be developed and tested. The utilization and amendment of local space resources, e.g. martian soil or lunar regolith, for agricultural and other purposes will be necessary if we are to minimize the requirement for Earth materials in the creation of long-term off-planet bases and habitations. Several of the roles soil plays in Biosphere 2 are (1) for air purification (2) as a key component in created wetland systems to recycle human and animal wastes and (3) as nutrient base for a sustainable agricultural cropping program. Initial results from the Biosphere 2 closure experiment are presented. These include the accelerated cycling rates due to small reservoir sizes, strong diurnal and seasonal fluxes in atmospheric CO2, an unexpected and continuing decline in atmospheric oxyge, overall maintenance of low levels of trace gases, recycling of waste waters through biological regeneration systems, and operation of an agriculture designed to provide divers and nutritionally adequate diets for crew members. Author (revised by Herner)

A95-95019
SET OF REACHABLE POSITIONS FOR A CAR
PHILIPPE SOUERES LAAS/CNRS, Toulouse, France, JEAN-YVES FOURQUET, and JEAN-PAUL LAUMOND IEEE Transactions on Automatic Control (ISSN 0018-9286) vol. 39, no. 8 August 1994 p. 1626-1630 refs
(BTN-95-EIX95332423428)

This paper shows how to compute the reachable positions for a model of a car with a lower bounded turning radius that moves forward and backward with a constant velocity. First, we compute the shortest paths when the starting configuration (i.e., position and direction) is completely specified and the goal is only defined by the position with the direction being arbitrary. Then we compute the boundary of the region reachable by such paths. Such results are useful in motion planning for nonholonomic mobile robot. Author (EI)

A95-95038
INFORMATION PRESENTATION FOR EXPERT SYSTEMS IN FUTURE AIRCRAFT COCKPITS
ESIN O. KIRIS Texas Tech Univ., Lubbock, TX, US and MICA R. ENDSLEY Texas Tech Univ., Lubbock, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 27-32 Research sponsored by the Association of Aviation Psychologists

This paper presents research on the use of expert systems for decision support in future aircraft systems. The objective of the research was to determine a pilot compatible method for presenting confidence level information associated with recommendations by an expert system. Forty five university students served as subjects in the study. Two types of decisions tasks were presented, for which expert system support was provided: (1) Radar displays of enemy aircraft and (2) a real world driving task. For each scenario, the expert system presented three possible actions along with the system's confidence in each alternative shown in one of five ways: no information (control); categorical (high, medium or low); ranks (1, 2, or 3); digital; and analog (thermometers). Time to make a decision, correctness and subjective confidence about the correctness of their decisions was measured at the end of each task. Results of an ANOVA showed a significant effect of task type, presentation type and a task by presentation interaction. Digital and analog forms of presentation increased decision making time and increased subjective confidence in both aircraft and automobile scenarios as compared to no confidence information. Author (Herner)

A95-95039
ELECTRONIC INSTRUMENT APPROACH PLATES: THE EFFECT OF SELECTIVE DECLUTTERING ON FLIGHT CREW PERFORMANCE
MARK G. MYKITYSHYN Massachusetts Inst. of Tech., MA, US and R. JOHN HANSMAN, JR. Massachusetts Inst. of Tech., MA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 33-37
(Contract(s)/Grant(s): DTRS-57-88C-00078)

Clutter problems that exist on current paper Instrument Approach Plates (IAPs) will be exacerbated when this information is presented electronically. In response, a methodology for chart decluttering has been developed based on an object oriented data structure. The information on the chart is grouped into several operationally related layers which can be selected or deselected for presentation by the pilot. This study investigates the effects of information selectability on pilot performance and preferences. An

experiment was conducted using the MIT part task simulator to record pilot performance and preferences in Electronic IAP (EIAP) related information retrieval tasks using both selectable and non-selectable charts. Performance was measured in terms of the speed and accuracy of extracting information from the EIAP. Information selectability patterns, response time, and error rate data were recorded for information retrieval questions. Qualitative observations concerning selectable versus non-selectable EIAPs were also solicited. Author (revised by Herner)

A95-95040* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HUMAN ENGINEERING ANALYSIS FOR THE HIGH SPEED CIVIL TRANSPORT FLIGHT DECK
DAVID M. REGAL Boeing Commercial Airplane Group, Seattle, WA, US and KEITH W. ALTER Boeing Commercial Airplane Group, Seattle, WA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 38-41
(Contract(s)/Grant(s): NAS1-18027; NAS1-19360)
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The Boeing Company is investigating the feasibility of building a second generation supersonic transport. If current studies support its viability, this airplane, known as the High Speed Civil Transport (HSCT), could be launched early in the next century. The HSCT will cruise at Mach 2.4, be over 300 feet long, have an initial range of between 5000 and 6000 NM, and carry approximately 300 passengers. We are presently involved in developing an advanced flight deck for the HSCT. As part of this effort we are undertaking a human engineering analysis that involves a top-down, mission driven approach that will allow a systematic determination of flight deck functional and information requirements. The present paper describes this work. Author (Herner)

A95-95042
A COMPARISON OF PERFORMANCE WITH VISUAL AND AUDITORY DISPLAYS IN A SIMULATED TARGET LOCALIZATION TASK
NANCY J. DOLAN Univ. of Dayton Research Inst., Dayton, OH, US, MAXWELL WELLS Logicon Tech. Services, Dayton, OH, US, and ROBERT OSGOOD Wright-Patterson AFB, Dayton, OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 49-53
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As aircraft cockpits becomes more complex, the number of displays needed to represent real-world events increases, thus increasing the perceptual and cognitive demands placed on a pilot. This paper discusses the feasibility of using auditory displays which provide location information to enhance the pilot-vehicle interface. Concurrent tasks which share the same pool of resources (e.g., two visual tasks) interfere with each other more than concurrent tasks that do not (e.g. a visual task and an auditory task). Author (Herner)

A95-95043
THE EFFECT OF PSEUDO THREE-DIMENSIONAL DISPLAYS ON THE TYPE AND QUALITY OF GENERAL AVIATION PILOTS' MANEUVERING DECISIONS
J. A. WISE Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, D. J. GARLAND Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US, and P. C. GUIDE Embry-Riddle Aeronautical Univ., Daytona Beach, FL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 54-57
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The availability of 3-D data bases for aerial navigation and the low cost of relevant display technology has made the display of 3-D navigation data to the pilot a near term probability. This paper looks at one basic issue associated with the application of such technology in the cockpit; how 3-D display of navigation data affects pilot decision making. It specifically investigates the impact that a pseudo three-dimensional display of airspace restrictions will have on the quality and types of decisions made by general aviation pilots when trying to maneuver through controlled airspace. Author (revised by Herner)

A95-95045
FAILURE INDICATIONS ON A HEAD-UP DISPLAY
KRISTEN K. LIGGETT Wright-Patterson Air Force Base, OH, US, JOHN M. REISING Wright-Patterson Air Force Base, OH, US, and DAVID C. HARTSOCK Midwest Systems Research, Inc., Dayton, OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 64-69
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The Air Force is developing Head Up Display (HUD) symbology which is intended to become the standard for future aircraft. The purpose of this study was to compare different methods to indicate failures of two sets of information on the HUD. A failure with the pitch and bank steering bars was implemented by: (1) putting small X's through the bar, or (2) placing gaps in the bar. A failure in the airspeed and altitude indicators was implemented by: (1) replacing the digital readout of the numbers with small X's, or (2) placing a big X over the entire indicator. The use of a Master Caution message was also analyzed. Results showed that, in terms of the pitch and bank steering bar failures, the small X's resulted in significantly quicker reaction time to the failure. Also, the use of the Master Caution message was preferred by the pilots, and trends indicate that performance increased when using the Master Caution message. In terms of airspeed and altitude indicator failures, there was no significant difference between small X's or big X's. Trends indicate that the best performance occurred when using the big X and when the Master Caution message was presented. Author (revised by Herner)

A95-95048* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HEAD-UP DISPLAYS: EFFECT OF INFORMATION LOCATION ON THE PROCESSING OF SUPERIMPOSED SYMBOLOGY
BEVERLY D. SANFORD CTA Inc., Moffett Field, CA, US, DAVID C. FOYLE NASA. Ames Research Center, Moffett Field, CA, US, ROBERT S. MCCANN Sterling Software, Palo Alto, CA, US, and KEVIN JORDAN San Jose State Univ., San Jose, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 81-87
(Contract(s)/Grant(s): NCC2-327)
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Head-up display (HUD) symbology superimposes vehicle status information onto the external terrain, providing simultaneous visual access to both sources of information. Relative to a baseline condition in which the superimposed altitude indicator was omitted, altitude maintenance was improved by the presence of the altitude indicator, and this improvement was the same magnitude regardless of the position of the altitude indicator on the screen. However, a concurrent decifit in heading maintenance was observed only when the altitude indicator was proximal to the path information. These results did not support a model of the concurrent processing deficit based on an inability to attend to multiple locations in parallel. They are consistent with previous claims that the deficit is the product of attentional limits on subjects' ability to process two separate objects (HUD symbology and terrain information) concurrently. The absence of a performance tradeoff when the HUD and the path information were less proximal is attributed to a breaking of attentional tunneling on the HUD, possibly due to eye movements.
Author (revised by Herner)

A95-95049
HUMAN-CENTERED REQUIREMENTS FOR ADVANCED COMMERCIAL TRANSPORT FLIGHT DECKS
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Seattle, WA, US, PATRICK M. HARPER Boeing Commercial Airplane Group, Seattle, WA, US, and KEITH W. ALTER Boeing Commercial Airplane Group, Seattle, WA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 88-92
Copyright

The paper focuses on the human factors research conducted on advanced flight deck 'glass cockpit' commercial transport airplanes and the resulting findings and recommendations. A critical assessment of a number of studies is presented in order to help identify any special human factors requirements for future advanced commercial transport flight decks. None of the findings support any major change away from the current evolutionary approach to flight deck development. Author (revised by Herner)

A95-95050
DESIGN AND EVALUATION OF INSTRUMENT APPROACH PROCEDURE CHARTS
M. STEPHEN HUNTLEY US DOT, Cambridge, MA, US and DAVID W. OSBORNE US DOT, Cambridge, MA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 93-97 Research sponsored by the Federal Aviation Administration
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A new format for instrument approach procedure charts has been designed. Special attention was paid to improving the readability of communication frequencies, approach course heading, and missed approach instructions. Selected components of the new design were evaluated in the laboratory. Other details, including design trade-offs, were determined from expert opinion. One version of the new chart is intended for use by large air carriers. A field evaluation of this chart is being conducted through the combined efforts of the federal government, a commercial publisher of instrument approach plates, and several major airlines. Author (Herner)

A95-95051
ENCODING ALTITUDE AND RATE INFORMATION IN COCKPIT DISPLAYS OF TRAFFIC INFORMATION: COLOR MY WORLD
DENNIS B. BERINGER New Mexico State Univ., NM, US and ROBERT C. ALLEN New Mexico State Univ., NM, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 103-107
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The effective use of cockpit displays of traffic information is largely dependent upon the degree to which vertical status and trend information can be presented simply and unambiguously to the pilot. An approach is to use color encoding techniques to represent vertical trend information in a plan-view horizontal situation display. Static and dynamic color coding techniques were used in such a display where stratified vertical sectors were represented by stereotypic colors (green/safe; yellow/caution; red/danger). The static representation depicted the symbol in the appropriate color or a 50/50 combination of colors to represent transitions between zones. The dynamic presentation used a continuously changing ratio of colors within the symbol to show this same transition between altitude zones as an attempt to provide rate and depth-of-penetration cues. Performances of nonpilots using these displays were obtained in a simulation setting and compared with performances obtained using numeric/symbolic encoding of the same information. The color-encoded conditions generally produced faster and more accurate classification responses than did the numeric/symbolic condition. Author (revised by Herner)

A95-95052
SYNTHETIC TERRAIN IMAGERY FOR HELMET-MOUNTED DISPLAY
WILLIAM H. CORWIN Honeywell SRC, US, ANDREW PROBERT Wright Labs, US, and RICK ROYER Lockheed-Ft. Worth, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 108-114
Copyright

A study was conducted to determine if synthetically derived terrain imagery, projected as background on a Helmet-Mounted Display, aids the pilot with maintaining spatial situation awareness. The U.S. Defense Mapping Agency's digital terrain elevation database (100 meter resolution) provides the terrain elevation information required to render a synthetic image of the surrounding environment. An F-16 simulator was used to conduct the evaluation. Different formats, sampling densities, and view volumes, were systematically varied to determine subjective pilot preference. Author (Herner)

A95-95053
FLIGHT DECK INFORMATION MANAGEMENT: AN EXPERIMENT STUDY OF FUNCTIONAL INTEGRATION OF APPROACH DATA
ELFIE F. HOFER Boeing Commercial Airplane Group, Seattle, WA, US, LEYSIA A. PALEN Boeing Commercial Airplane Group, Seattle, WA, US, and ANTONIO POSSOLO Boeing Computer Services, Seattle, WA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 119-125 Research sponsored by the FAA Flight Crew Systems Research Branch
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Existing and emerging flight deck information management technologies offer increased storage and processing power, potentially increasing the supply of required and desired information. To ensure that the operators' information processing strengths and limitations are fully taken into consideration, consistent, human-centered flight deck information management schemes need to be devised for normal flight deck operations. It was our goal to develop guidelines for the categorization, prioritization, and display of information required in normal flight deck operations, based on the results of part-task flight simulation testing. Several information display formats were developed and validated in an information retrieval task and in an actual flying task. Author (revised by Herner)

A95-95056* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE EFFECTS OF PLAN-BASED DISPLAYS IN COMMERCIAL AVIATION
VALERIE L. SHALIN SUNY at Buffalo, Buffalo, NY, US, BRIAN G. MIKESELL SUNY at Buffalo, Buffalo, NY, US, MAYA RAMAMURTHY SUNY at Buffalo, Buffalo, NY, US, and NORMAN D. GEDDES Applied Systems Intelligence, Inc., Gainesville, GA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 138-143
(Contract(s)/Grant(s): NAG1-1342)
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The experiment reported here examines the performance consequences of alignment between display formats and the methods used during descent. Twelve commercial pilots flew one of nine Standard Terminal Arrival Routes on a stand-alone flight simulator run on a Sparc II workstation. Three different methods for descent (Manual Control, Autopilot and Spoilers) were crossed with three methods according to scope, resolution, and bandwidth properties in the display of critical information. Performance variability in speed control supports our claim that the effectiveness of a display is not an independent property of the display itself, but rather, a function of the interaction of the display and the particular methods used for achieving task goals. Author (Herner)

A95-95057
EFFECTS OF ALLOCATION AND PARTITIONING STRATEGIES OF ADAPTIVE AUTOMATION ON TASKPERFORMANCE AND PERCEIVED WORKLOAD IN

AVIATION RELEVANT TASKS

J. P. GLUCKMAN Naval Air Warfare Center, Warminster, PA, US, M. A. CARMODY Naval Air Warfare Center, Warminster, PA, US, J. G. MORRISON Naval Air Warfare Center, Warminster, PA, US, E. M. HITCHCOCK Naval Air Warfare Center, Warminster, PA, US, and J. S. WARM Univ. of Cincinnati, Cincinnati, OH, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 150-155

Strategies for adaptive automation were studied in terms of their effects on performance and workload. The Multi-Attribute Task Battery (MAT) was employed for this study because it allows extensive inquiries regarding human information-processing in the presence of automation. Specifically, this study assessed the effects on performance and workload of automation strategies which vary the degree of operator control (no automation, partial or aided automation, and full automation) for tasks which differ on their stability with respect to time. A second objective of this experiment was to assess the use of a workload scale developed using aspects of the NASA Task Load Index (NASA-TLX) and the Subjective Workload Dominance (SWORD) techniques. The results suggest that the significant differences in operators ability to perform tasks, as well as their ratings of subjective workload, are affected by both the extent to which they maintain active control of the task and the stability of the task that is automated. Author (Herner)

A95-95058* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EFFECT OF TASK LOAD AND TASK LOAD INCREMENT ON PERFORMANCE AND WORKLOAD

P. A. HANCOCK Univ. of Minnesota, MN, US and G. WILLIAMS Univ. of Minnesota, MN, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 156-160 Research sponsored by NAWC
(Contract(s)/Grant(s): NAG2-749)

The goal of adaptive automated task allocation is the 'seamless' transfer of work demand between human and machine. Clearly, at the present time, we are far from this objective. One of the barriers to achieving effortless human-machine symbiosis is an inadequate understanding of the way in which operators themselves seek to reallocate demand among their own personal 'resources.' The paper addresses this through an examination of workload response, which scales an individual's reaction to common levels of experienced external demand. The results indicate the primary driver of performance is the absolute level of task demand over the increment in that demand. Author (revised by Herner)

A95-95059* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

OPERATOR VERSUS COMPUTER CONTROL OF ADAPTIVE AUTOMATION

BRIAN HILBURN Catholic Univ. of America, Washington, DC, US, ROBERT MOLLOY Catholic Univ. of America, Washington, DC, US, DICK WONG Catholic Univ. of America, Washington, DC, US, and RAJA PARASURAMAN Catholic Univ. of America, Washington, DC, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 161-166 Research sponsored by NAWC
(Contract(s)/Grant(s): NAG1-1296)

Adaptive automation refers to real-time allocation of functions between the human operator and automated subsystems. The article reports the results of a series of experiments whose aim is to examine the effects of adaptive automation on operator performance during multi-task flight simulation, and to provide an empirical basis for evaluations of different forms of adaptive logic. The combined results of these studies suggest several things. First, it appears that either excessively long, or excessively short, adaptation cycles can limit the effectiveness of adaptive automation in enhancing operator performance of both primary flight and monitoring tasks. Second, occasional brief reversions to manual control can counter some of the monitoring inefficiency typically associated with long cycle automation, and further, that benefits of such reversions can be sustained for some time after return to automated control. Third, no evidence was found that the benefits of such reversions depend on the adaptive logic by which long-cycle adaptive switches are triggered. Author (revised by Herner)

A95-95060

TASK SPECIFIC EFFECTS OF AUTOMATION AND AUTOMATION FAILURE ON PERFORMANCE, WORKLOAD, AND SITUATION AWARENESS

MEGHAN A. CARMODY Naval Air Warfare Center, Warminster, PA, US and JONATHAN P. GLUCKMAN Naval Air Warfare Center, Warminster, PA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 167-171

The present study investigated the effects of automating different aviation-relevant tasks on human performance in regaining manual control following automation failure. The investigation employed a version of the Multi-Attribute Task (MAT) Battery which presents subjects three aviation-relevant tasks: a Compensatory Tracking task, a System Monitoring task, and a Fuel Management task. Specifically, this study examined the effects on performance, workload, and situation awareness of removing the human operator 'from the loop' for long periods of time and then requiring him/her to suddenly reenter that 'loop'. Results indicated task-specific effects of automation on performance and situational awareness. Such effects are discussed with respect to the unique information-processing characteristics of the tasks involved, particularly the dynamic versus stable nature of the internal cognitive model associated with decision-making within a task. Author (Herner)

A95-95061

PROSPECTIVE PRINCIPLES AND GUIDELINES FOR THE DESIGN OF ADAPTIVELY AUTOMATED CREWSTATIONS

JEFFREY G. MORRISON Naval Air Warfare Center, Warminster, PA, US, DAVID COHEN Naval Air Warfare Center, Warminster, PA, US, and JONATHAN P. GLUCKMAN Naval Air Warfare Center, Warminster, PA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 172-177

Adaptive automation (AA) is a technology that has been proposed to tailor automation to human requirements. AA, when applied to the pilot-vehicle interface, is expected to minimize the negative effects of fixed automation while optimizing pilot performance. It is unclear, however, how AA should be designed to ensure optimal performance. This paper provides a review of an ongoing human factors research program that has the objective of providing a strong empirical foundation for the introduction of AA. A taxonomy for conceptualizing the design of AA systems is described and 14 prospective, research-based principles and guidelines for the implementation of AA are presented. Author (Herner)

A95-95062* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ADAPTIVE FUNCTION ALLOCATION REDUCES PERFORMANCE COSTS OF STATIC AUTOMATION

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(Contract(s)/Grant(s): NAG1-1296)

Adaptive automation offers the option of flexible function allocation between the pilot and on-board computer systems. One of the important claims for the superiority of adaptive over static automation is that such systems do not suffer from some of the drawbacks associated with conventional function allocation. Several experiments designed to test this claim are reported in this article. The efficacy of adaptive function allocation was examined using a laboratory flight-simulation task involving multiple functions of tracking, fuel-management, and systems monitoring. The results show that monitoring inefficiency represents one of the performance costs of static automation. Adaptive function allocation can reduce the performance cost associated with long-term static automation. Author (revised by Herner)

A95-95064* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EMPIRICAL EVAULATION OF COMPUTERIZED TOOLS TO AID IN ENROUTE FLIGHT PLANNING
PHILIP J. SMITH Ohio State Univ., Columbus, OH, US, C. ELAINE MCCOY Univ. of Nebraska at Omaha, NE, US, and CHARLES LAYTON Galaxy Scientific Corp., Atlanta, GA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 186-191
(Contract(s)/Grant(s): NCC2-615; NCA2-701)

The paper describes an experiment using the Flight Planning Testbed (FPT) in which 27 airline dispatchers were studied. Five general questions was addresses in the study: Under what circumstances does the introduction of computer-generated suggestions (flight plans) influence the planning behavior of dispatchers; what is the nature of such influences; How beneficial are the general design concepts underlying FPT; How effective are the specific implementation decisions made in realizing these general design concepts; How effectively do dispatchers evaluate situations requiring replanning and how effectively do they identify appropriate solutions to these situations. The study leaves little doubt that the introduction of computer-generated suggestions for solving a flight planning problem can have a marked impact on the cognitive processes of the user and on the ultimate plan selected. Author (revised by Herner)

A95-95082
NATURAL SCENE TEMPLATES AS CUEING DEVICES
JAN STIFF Naval Air Warfare Center, China Lake, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 302-306

This experiment examined the speed and accuracy with which operators could recognize a match between computer generated line drawings (also called templates) and digitized photographic images. The findings of this experiment indicate that using these natural scene templates as cueing devices may provide an effective means of informing pilots that a target or offset aim point has been found. Average response times in this experiment varied from 3 to 5 seconds. These times were significantly affected by both template color and the presence or absence of rotation in the template. Accuracy ranged from 81 to 98 percent correct responses with most test conditions falling above 93%. Accuracy was significantly affected by the type of presentation format used and by the presence or absence or rotation in the template. Author (Herner)

A95-95086
DELAYED PILOT RECOGNITION IN LOST COMMUNICATION EVENTS
CHARLES R. DREW Battelle/ASRS, Mountain View, CA, US, ANDREW D. SCOTT Battelle/ASRS, Mountain View, CA, US, and ROBERT D. MATCHETTE Battelle/ASRS, Mountain View, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 318-323

Early detection in loss of communication events would likely reduce the risks associated with these incidents. This project re-evaluated 200 records in an effort to determine the principal human-factors issues involved in delayed recognition of interrupted communication incidents. We examine issues such as levels-of-attention, workload and flight phase, confusion, and situational awareness. The five specific objectives of this research project were to: (1) Relate the causes and results of lost-com events to the flight phases in which these events occur, (2) Examine the human agent as a causative and contributing factor in lost communication incidents, (3) Identify the environmental factors influencing human performance in these events, (4) Examine the human as a detector and resolver of these problems, (5) Suggest methods by which event recognition and correction may be facilitated. Author (Herner)

A95-95087* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE INFLUENCE OF AIR TRAFFIC CONTROL MESSAGE LENGTH AND TIMING ON PILOT COMMUNICATION
DANIEL MORROW Decision Systems, Los Altos, CA, US and MICHELLE RODVOLD San Jose State Univ. Foundation, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 324-327 Research sponsored by NASA. Ames Research Center

The present paper outlines an approach to air traffic control (ATC) communication that is based on theories of dialogue organization and describes several steps or phases in routine controller-pilot communication. The introduction also describes several kinds of communication problems that often disrupt these steps, as well as how these problems may be caused by factors related to ATC messages, the communication medium (radio vs. data link) and task workload. Next, a part-task simulation study is described. This study focused on how problems in radio communication are related to message factors. More specifically, we examined if pilots are more likely to misunderstanding longer ATC messages. A more general goal of the study is to show that communication analysis can help trace where problem occur and why. Author (Herner)

A95-95088* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPROVING SITUATION AWARENESS DISPLAYS FOR AIR TRAFFIC CONTROLLERS
JAMES C. JOHNSTON NASA. Ames Research Center, Moffett Field, CA, US, KRISTA L. HORLITZ NASA. Ames Research Center, Moffett Field, CA, US, and ROBERT W. EDMISTON NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 328-334

Situation awareness displays play a critical role in the performance of air traffic controllers, but present versions are far from ideal. One problem is the use of alphanumeric datablocks for critical information such as altitude and speed. Reading datablocks is cumbersome and time-consuming, and additional cognitive effort is required to retain and use the information obtained. We investigated redundant pictorial display of datablock information. Four experiments tested different schemes for depicting altitude. The performance measure was the time to find a target aircraft whose altitude was within 1000 feet of a cued aircraft. Color-coding of altitude (either discrete bands or continuously varying hues) substantially improved performance. A variety of achromatic pictorial codes for altitude (including size, intensity and micro-texture pattern) produced modest improvement or none at all. Icons that provide an

integrated perceptual reprensation of aircraft altitude, altitude change, speed, and projected path are discussed. Author (Herner)

A95-95089
THE ROLE OF EXPERT SYSTEMS IN FUTURE COOPERATIVE TOOLS FOR AIR TRAFFIC CONTROLLERS
MARCEL LEROUX CENA, France *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 335-340
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Since automation cannot replace human operators, it must assist them. This is one of the paradoxes of automation, as needed by the air traffic control (ATC) system: as long as full automation feasibility and efficiency is not proved, it is essential to preserve the controllers' skills. Whatever tools are designed, human controllers must exercise their skills continuously. In this paper we will discuss two standard metaphors concerning Man-Machine Cooperation: machines considered as prostheses or as instruments. Technological development has moved from physical tools to perceptual tools and now, with the arrival of artificial intelligence (AI) technology, to cognitive tools. The question of the relationship between humans and machines takes the form of what kind of tool an intelligent machine is. At one extreme, the machine can be a prosthesis that compensates for a deficiency in human reasoning or problem solving. At the other extreme, the machine can be an instrument in the hands of a fundamentally competent but limited-resource human practitioner. Author (Herner)

A95-95092
THE BEHAVIORAL IMPACT OF TCAS II ON THE NATIONAL AIR TRAFFIC CONTROL SYSTEM
V. J. MELLONE and S. M. FRANK *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 352-359
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The objectives of the research were to analyze the effects of Traffic Alert and Collision Avoidance System (TCAS II) avoidance applications on pilot-controller interactions and to suggest strategies that could promote a more harmonious human-technology juncture. If verified the following points: TCAS II has definitely ehanced flight safety; Initial TCAS II training did not adequately prepare pilots and controllers for the 'surprises' generated during Resolution Advisory (RA) situations; TCAS II applications have had an impact on the roles of pilot and controller; Behavioral ramifications need to be fully evaluated in concert with ergonomic issues. Author (revised by Herner)

A95-95093* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PRELIMINARY ANALYSIS OF PILOT RATINGS OF 'PART LINE' INFORMATION IMPORTANCE
AMY PRITCHETT Massachusetts Inst. of Tech., US and R. JOHN HANSMAN Massachusetts Inst. of Tech., US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 360-366
(Contract(s)/Grant(s): NAG2-716)
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With the introduction of digital datalink communications into the Air Traffic Control (ATC) system, there is concern over the potential loss of situational awareness by flight crews due to the reduction in the 'Party Line Information' (PLI). This information is available to the pilot by overhearing communications between ATC and other aircraft. A survey was distributed to determine current PLI use by several pilot operational groups, experience levels and geographic regions. The survey identified numerous important elements. PLI was rated the highest for operations near or on approach to the airport. Several significant variations were found between pilots from different operational groups and experience levels. Traffic and weather information were the most frequently cited as information required to obtain global situation awareness. Author (Herner)

A95-95094
AN EVALUATION OF PERSPECTIVE AND STEREOSCOPIC DISPLAYS AS ALTERNATIVES TO PLAN VIEW DISPLAYS IN AIR TRAFFIC CONTROL
MINGPO THAM Univ. of Illinois, Savoy, IL, US, CHRISTOPHER WICKENS Univ. of Illinois, Savoy, IL, US, CRYSTAL LIANG Univ. of Illinois, Savoy, IL, US, JEFFRY LONG Univ. of Illinois, Savoy, IL, US, and RONALD CARBONARI Univ. of Illinois, Savoy, IL, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 367-372
(Contract(s)/Grant(s): DTFA01-91-C-0045)
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Two experiments were conducted to examine the performance of Air Traffic Controllers (ATCO) and non-ATCO subjects on Plan View (PVD), Perspective (PER/PER-0), and Stereoscopic (ST) radar displays. Experiment 1 was a partial-task design where the subjects performed judgment tasks in a Terminal Radar Approach Control (TRACON) simulation. Experiment 2 was a whole-task design and the subjects performed the task of an approach and departure controller in the simulated TRACON. The results from Experiment 1 suggested that there were significant decrements in the judgment of speed and heading, and determining altitude from the data tags in the PER and ST displays. Preliminary analyses of the results from Experiment 2 show that there was no significant difference in the subjects performance on the different displays although ATCOs issued more heading-change instructions on the PVD. Author (Herner)

A95-95095
COMPUTER HUMAN INTERFACE DESIGN IN TOWER AIR TRAFFIC CONTROL FOR AIRCRAFT FLIGHT DATA MANAGEMENT
DOUGLAS L. MILLER Federal Systems Co., Rockville, MD, US and G. JONATHAN WOLFMAN Federal Systems Co., Rockville, MD, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 372a-372e
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The Tower Control Computer Complex (TCCC) will introduce advanced workstations and software to the air traffic control tower. The most controversial and visible aspect of the TCCC has been introduction of electronic flight data management to the tower. Flight data management is the vehicle by which tower controllers plan, track, and record aircraft movements. This paper provides an overview of the TCCC computer-human interface (CHI) design for flight data management, and several associated issues. Of the five workstation input devices, three (speech recognition, touch screens, and control grip device) have been included to perform specific flight data management tasks. The software design embodies predictable aircraft movements and controller actions as aircraft states which, in turn, provide a vehicle for tailoring the display of information to meet the current operator needs. State transitions provide a similar vehicle for editing, highlighting, and transferring flight data with minimal controller workload. Author (revised by Herner)

A95-95099
COMMERCIAL FLIGHT CREW SELECTION FOR AUTOMATED FLIGHT DECKS
RONALD E. CLARK Embry-Riddle Aeronautical Univ., US and WILLIAM F. HERLEHY, III Embry-Riddle Aeronautical Univ., US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 404-409
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Automation and human-computer interface (HCI), as they affect flight crew selection criteria, are a central focus of this paper. The research plan of this paper has three components: First, the

authors conducted an extensive literature review of recent publications concerning flight deck automation and flight crew selection. Second, a small 'expert' sample of aircraft design engineers, flight crew selection personnel and human factors specialists were interviewed. Third, a small sample of aviation psychology and human factors 'expert' were surveyed. The review provided a baseline of industry research and development ('R & D') knowledge, while the expert interviews and surveys provided specific parameters, concerns and a 'cutting edge' focus. Author (revised by Hemer)

A95-95124* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HUMAN FACTORS IN INCIDENT REPORTING
S. G. JONES NASA/Univ. of Texas/FAA, Austin, TX, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 567-572 Research sponsored by FAA (Contract(s)/Grant(s): NCC2-286)

The paper proposes a cooperative research effort be undertaken by academic institutions and industry organizations toward the compilation of a human factors data base in conjunction with technical information. Team members in any discipline can benefit and learn from observing positive examples of decision making and performance by crews under stressful or less than optimal circumstances. The opportunity to note trends in interpersonal and interactive behaviors and to categorize them is terms of more or less desirable outcomes should not be missed.
Author (revised by Hemer)

A95-95126* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AUTOMATION DESIGN AND CREW COORDINATION
LEON D. SEGAL Univ. of Illinois at Urbana-Champaign, Urbana, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 578-583 (Contract(s)/Grant(s): NCA2-616)

Advances in technology have greatly impacted the appearance of the modern aircraft cockpit. Where once one would see rows upon rows. The introduction of automation has greatly altered the demands on the pilots and the dynamics of aircrew task performance. While engineers and designers continue to implement the latest technological innovations in the cockpit - claiming higher reliability and decreased workload - a large percentage of aircraft accidents are still attributed to human error. Rather than being the main instigators of accidents, operators tend to be the inheritors of system defects created by poor design, incorrect installation, faulty maintenance and bad management decisions. This paper looks at some of the variables that need to be considered if we are to eliminate at least one of these inheritances - poor design. Specifically, this paper describes the first part of a comprehensive study aimed at identifying the effects of automation on crew coordination.
Author (revised by Hemer)

A95-95134
ON-BOARD CREW-REST FACILITIES
HANS DE REE KLM Royal Dutch Airlines (SPL/AY), Schiphol, Netherlands, RIES SIMONS Netherlands Aerospace Medical Center, Soesterberg, Netherlands, and PIERRE VALK Netherlands Aerospace Medical Center, Soesterberg, Netherlands *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 639-644

As a first phase of a study to evaluate on-board crew-rest facilities a questionnaire was distributed among flight deck and cabin crew members. The aim was to assess subjective appreciation of the facilities. Response rate was 65%(N = 167) for flight deck crew and 31%(N = 1109) for cabin crew. The general attitude towards the rest facilities is highly positive, despite the influence of a range of factors that interfere with sleep such as climate, noise, scheduling of rest periods and command responsibility. The results are discussed in terms of implications for further research and future specification of rest facilities. Author (Hemer)

A95-95166
TRACKING THE VISUAL SCAN OF AIR TRAFFIC CONTROLLERS
EARL S. STEIN DOT/FAA Technical Center, Atlantic City, NJ, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 812-816

Air traffic control is a visually intensive effort requiring a great deal of concentration. A controller must scan, detect, plan, decide, and communicate. There is currently no mandated strategy for scanning radar display and each controller develops his/her own. The purpose of this study was to explore the possibility that scanning patterns were somehow related to experience. Ten controllers each worked simulated traffic in a radar environment. Eye movements were measured using an oculometer. Results indicated that both groups changed their scanning patterns as the traffic built up over time, with final patterns being very much driven by the flow of traffic. Once the traffic pattern was establish, there were very few scans outside the pattern. Further, the newer controllers scanned less frequently and fixated longer, which indicates basically that they covered less airspace. They also had a higher frequency of conflicts between their sectors and those adjacent to them. This could have resulted from less scanning on the peripheral portions of the radar display. Author (revised by Hemer)

A95-95176* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ATTENTIONAL TUNNELING AND THE HEAD-UP DISPLAY
CHRISTOPHER D. WICKENS Univ. of Illinois at Urbana-Champaign, Savoy, IL, US, ROBIN MARTIN-EMERSON Univ. of Illinois at Urbana-Champaign, Savoy, IL, US, and INGE LARISH Univ. of Illinois at Urbana-Champaign, Savoy, IL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 865-870
(Contract(s)/Grant(s): NAG2-375)

Twenty instrument-rated flight students flew simulated landing approaches to a realistic graphics generated airport, using either a head-up display (HUD) of instrument landing systems (ILS) instruments or the same display positioned 8.5 deg. head down. Responses to discrete events appearing either on the ground environment or on the instrument display assessed the pilot's ability to switch attention between these domains. Unexpected events also occurred once (per subject) in each domain. The results revealed that flight path control and attention switching to the instrumnet display was better supported by the HUD, while this advantage disappeared for attention switching to the environment, and for detection of unexpected events. The results are discussed in terms of the attention strategies employed in sampling multiple information sources. Author (Hemer)

A95-95180
EVALUATION OF TWO INFLIGHT SENSORS USING HEART RATE AND EYE BLINK MEASURES
GLENN F. WILSON Amstrong Lab. at Wright-Patterson AFB, OH, US, ALBERT BADEAU Amstrong Lab. at Wright-Patterson AFB, OH, US, and VALERIE GAWRON Arvin/Calspan Corp., US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 886-890

The ease of obtaining information from visual displays impacts operator workload and situational awareness. In general, heart rate

has been found to increase with situations requiring increased mental resources while blink rate and blink closure durations decrease with increased visual demands. We have conducted a study with test pilot students while they flew training flights using radar (RDR) and infrared (IR) sensors to identify elements of target arrays. Our question was whether or not the two types of sensors differed in their demands upon the operators. Heart rate and eye blinks were used to evaluate the operator demands of these systems.
Author (revised by Herner)

A95-95181
THE EFFECT OF TASKLOAD PROJECTION ON AUTOMATION USE, PERFORMANCE, AND WORKLOAD
W. C. HARRIS Univ. of Minnesota, Minneapolis, MN, US, P. A. HANCOCK Univ. of Minnesota, Minneapolis, MN, US, and E. J. ARTHUR Univ. of Minnesota, Minneapolis, MN, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University *April 1993 p. 890a-890f*
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In conditions where system performance is not demonstrably better during either automatic or manual modes, the question of when and how control is transferred is an important operational issue. The present experiment compares multi-task, optional automation performance during periods when upcoming taskload information is available with performance during periods when taskload projections are not available and examines the effect of fatigue on operator's use of optional automation. Author (revised by Herner)

A95-95199
MANAGEMENT OF HUMAN FAILURE IN THE COCKPIT BY MEANS OF A HUMAN SYSTEM FAILURE CHECKLIST
GEORGE WHITE Trinity College Dublin, Dublin, Ireland *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 981-984
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The introduction into airline service of a human system failure checklist, within the framework of existing standard operating procedures and as an integral part of normal checklist philosophy, is suggested. Many human malfunctions can now be identified, articulated and directed into a formalized and depersonalized system of control. The draft checklist deals with specific identified hazardous phases of flight, information reception/processing deficiences together with cognitive and behavioral problems. The stability of overall annual accident rates is noted, together with the significant regional variations. The value of the proposed simple direct intervention is argued. Airline assistance in future research is solicited. Author (Herner)

A95-95205
USE OF ASRS DATA IN AN ARLINE HUMAN FACTORS DEPARTMENT
ELIZABETH A. LYALL America West Airline, Phoenix, AZ, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1025-1027
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The incident data available from searches through the Aviation Safety Reporting System (ASRS) are invaluable in many areas addressed by our Human Factors department at America West Airlines, especially those areas focusing on changes to operational procedures or developing flight crew training programs. ASRS data are used, in addition to in-house information sources, to take a proactive approach to preventing safety-related problems that face America West, as well as other carriers. The ASRS data of most interest to us are those that affect all aircraft and operations, such as crew coordination or fatigue, and those that deal with operations similar to ours - especially those that occur on aircraft types that we operate. ASRS information has been used, not only to document problems encountered throughout the industry, but also to gather ideas on possible directions that may be taken to solve particular operational or training problems. Those areas where the ASRS data have been particularly helpful are highlighted, including applications in development of flight crew training programs and operational procedures, and those addressing particular research issues determined to be of benefit to the airline. Author (Herner)

A95-95207
HUMAN FACTORS TRAINING FOR THE INVESTIGATOR: THE RESULTS OF A SYSTEMS APPROACH TO TRAINING DEVELOPMENT
MAURY W. HILL Transportation Safety Board of Canada, Ottawa, Ontario, Canada *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1031-1038
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While the aviation community is adjusting to the importance of human factors in accident prevention, to date there has been little coherent effort to provide accident investigators with the requisite knowledge and skills to deal with human performance issues in a systematic way. Even when investigators do receive special training, the tendency has been to focus on the performance of those individuals closest to the operation at the time of the accident or incident. As a result, accident reports focus on the what, when where, and who of the occurrence. A factual travel log is often presented, component with a second-to-second examination of the crash dynamics. A lack of appropriate training has adversely affected the quality of our investigations and the identification of safety deficiencies. Author (Herner)

A95-95620
ABSORPTION AND STEAM DESORPTION PERFORMANCE OF WEAK BASE ANION EXCHANGE RESIN
YANWU YIN Institute of Medico, Beijing, China and SHUFAN QIU Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 27-31 In CHINESE
(HTN-95-93119) Copyright

Weak base anion exchange resin has the ability of removing and concentrating CO2 from the atmosphere, and thus is a candidate for CO2 removal and CO2 concentration in manned spacecraft. Concentrated CO2 can then be delivered to the CO2 reduction subsystem for oxygen recovery. A tubular packed-bed reactor was used and a series of experiments were conducted to investigate the CO2 absorption and desorption performance of four resin samples. First, the CO2 absorption capacities of the four resin samples were compared and the one which has the highest absorption capacity was selected to be further examined. Then the effects of five characteristic parameters on the dynamic CO2 absorption capacity of the selected resin were observed. The parameters were the temperature of the resin bed, the length of the flow path in the resin bed, the flowrate of the air inlet, the CO2 concentration and the relative humidity of the inlet air. Finally, the method of CO2 desorption by steam at ambient pressure (101 kPa) was evaluated. The results of the experiments indicated that the selected resin is a high performance regenerable CO2 absorbent that meets the requirements for manned spacecraft cabin atmosphere CO2 removal and concentration. Author (Herner)

A95-95621
MEDICAL OBSERVATION OF OXYGEN SUPPLY WITH SUPEROXIDE REGENERATION METHODS IN SIMULATED CABIN
ZHIPING ZHU Institute of Space Medico, Beijing, China, GUOLIN XU, XUEFU SHEN, XUFENG LUO, and QING WANG Space Medicine & Medical Engineering (ISSN 1002-0837) vol. 8, no. 1 March 1995 p. 32-36 In CHINESE
(HTN-95-93120) Copyright

This paper describes oxygen regeneration with chemical methods in simulated cabin environment and regulation of the composition of the cabin air by the control system. Physiological parameters of human gaseous metabolism were also discussed. These parameters are very important for evaluation of the relation between

human activity and cabin environment control and for further study of oxygen supply system in manned space cabin as well.
Author (Herner)

N95-30522 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Div. of Safety and Reliability.
SPECIFIC METHOD FOR TASK-BASED INTERACTION DESIGN
E. HOLLNAGEL, P. HOUGAARD, R. ROSNESS, T. PAULSEN, and O. OEGARD 1994 20 p Prepared in cooperation with Computer Resources International A/S, Denmark), and ESA. ESTEC, Noordwijk, Netherlands
(PB95-196440; STF75-S93007) Avail: Issuing Activity (National Technical Information Service (NTIS))

The developments in computers and information technology have led to a growing dependence on the proper functioning of human-machine interaction (HMI). It is therefore important that the design of HMI is addressed as a specific problem and that proper concepts and methods are developed. The design process serves to increase the constraints governing the situation so that only one option or alternative is left for each requirement. HMI design must therefore be supported by methods that can elicit the requirements, determine the constraints and options, and finally assist in achieving the proper combination of requirements and options that constitutes the desired solution. The paper describes such a method, based on a systematic task analysis. The design is developed based on a definition of the functional requirements which then are combined with information about presentation styles and standards and dialog design principles. The Task Based Interaction Design method is illustrated by an example from a space application. NTIS

N95-30552 Department of the Navy, Washington, DC.
RELEASEABLE UNCONSTRAINED INFLATABLE BODY PROTECTOR Patent
FREDERICK C. GUILL, inventor (to Navy) 8 Nov. 1994 8 p Filed 11 Aug. 1993
(AD-D017350; US-PATENT-5,362,098; US-PATENT-APPL-SN-104682; US-PATENT-CLASS-280) Avail: US Patent and Trademark Office

A device for providing crash protection to people aboard a land, air, sea or space vehicle is described. A crash sensor mounted on the vehicle is used to sense a crash, impact or jarring motion. Data from the crash sensor is then transmitted via wireless communication by a signal transmitter to a signal receiver mounted on a harness worn by a crew member or passenger. When a crash signal is received, inflation mechanisms inflate inflatable bladders mounted on the harness, thereby protection the person wearing the harness. DTIC

N95-30888# Air Force Systems Command, Wright-Patterson AFB, OH. National Air Intelligence Center.
WIDE FIELD OF VIEW HELMET DISPLAY SYSTEMS MOUNTED FOR HELICOPTER SIMULATION
LIN YI ZHONG 23 Mar. 1995 11 p Transl. into ENGLISH from Guoji Hangkong, China, no. 4, 6 p Apr. 1993
(AD-A293123; NAIC-ID(RS)T-0414-94) Avail: CASI HC A03/MF A01

The wide field of view helmet mounted display system with a broad detection span will have significant impact on future reconnaissance and military helicopter simulation. This paper briefly discusses its application with emphasis on visualization of extremely close objects/terrain during low-level flight, target display, and head aiming. CASI

N95-30907# Michigan State Univ., East Lansing, MI. Dept. of Biomechanics.
ERECT, NEUTRAL AND SLUMP SITTING POSTURES: A STUDY OF THE TORSO LINKAGE SYSTEM FROM SHOULDER TO HIP JOINT Final Report, Dec. 1983 - Dec. 1985
HERBERT M. REYNOLDS Oct. 1994 175 p
(Contract(s)/Grant(s): F33615-84-C-0507)
(AD-A293239; AL/CF-TR-1994-0151) Avail: CASI HC A08/MF A02

Sitting postures representative of a maximum erect, neutral and maximum slumped spinal curvature were defined by comparable anatomical pointmarks in three dimensional space. Nine, male, unembalmed cadavers were measured with a roentgen stereophotogrammetric system. The results describe thoracic and lumbar curvatures in three postures and the locations of specific landmarks representing the shoulder joint, spinal column, and hip joint in a three dimensional seat reference system. In addition to the three dimensional analysis of sitting posture, the range of notion for each motion segment measured in the spine was calculated. These data were used to evaluate the contribution of specific lumbar motion segments in the change of sitting posture from maximum erect to maximum slump. To evaluate the condition of each subject's musculoskeletal system, osteological, morphological and physiological procedures were used to describe the sample. DTIC

N95-31134*# *Cleveland State Univ., OH.*
DEVELOPMENT AND COMPUTER IMPLEMENTATION OF DESIGN/ANALYSIS TECHNIQUES FOR MULTILAYERED COMPOSITE STRUCTURES. PROBABILISTIC FIBER COMPOSITE MICROMECHANICS M.S. Thesis, Mar. 1987 Final Report, 1 Sep. 1984 - 1 Oct. 1990
THOMAS A. STOCK 19 Jun. 1995 193 p
(Contract(s)/Grant(s): NAG3-550)
(NASA-CR-198979; NAS 1.26:198979) Avail: CASI HC A09/MF A03

Probabilistic composite micromechanics methods are developed that simulate expected uncertainties in unidirectional fiber composite properties. These methods are in the form of computational procedures using Monte Carlo simulation. The variables in which uncertainties are accounted for include constituent and void volume ratios, constituent elastic properties and strengths, and fiber misalignment. A graphite/epoxy unidirectional composite (ply) is studied to demonstrate fiber composite material property variations induced by random changes expected at the material micro level. Regression results are presented to show the relative correlation between predictor and response variables in the study. These computational procedures make possible a formal description of anticipated random processes at the intraply level, and the related effects of these on composite properties. Author

N95-31267# Korea Cancer Center Hospital, Seoul (Republic of Korea).
THE DEVELOPMENT OF HUMAN BEHAVIOUR ANALYSIS TECHNIQUES AND THE DEVELOPMENT OF HUMAN FACTORS TECHNOLOGIES
JUNG WOON LEE (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), SE WOO CHEON (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), SANG MOON SHU (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), GEUN OK PARK (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), YONG HEE LEE (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), HAN YEONG LEE (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), JAE CHANG PARK (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), EU JIN LEE (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.), and SEUNG HEE LEE (Korean Atomic Energy Research Inst., Seoul, Republic of Korea.) Apr. 1994 250 p In KOREAN
(DE95-613356; KAERI/RR-1339/93) Avail: CASI HC A11/MF A03

This project has two major areas; one is the development of an operator task simulation software and another is the development of human error analysis and application technologies. In this year project, the second year, for the development of an operator task simulation software, we studied the following: - analysis of the characteristics of operator tasks, - development of operator task structures: Macro Structures, - development of an operator task simulation analyzes, - analysis of performance measures. And the following for the development of human error analysis and applica-

tion technologies: - analysis of human error mechanisms, - analysis of human error characteristics in tasks, - analysis of human error occurrence in Korean Nuclear Power Plants, - establishment of an experimental environment for human error data collection with Compact Nuclear Simulator, - basic design of a Multimedia-based Human Error Representing System. DOE

N95-31399 Federal Aviation Administration, Atlantic City, NJ.
HUMAN FACTORS AT THE FAA TECHNICAL CENTER: BIBLIOGRAPHY Technical Note, Dec. 1993 - Dec. 1994
EARL S. STEIN, ed., EDWARD BUCKLEY, ed., and KATHY MANN, ed. (Princeton Economic Research, Inc., NJ.) Dec. 1994 47 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A288638; DOT/FAA/CT-TN94/50) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

Since the Federal Aviation Administration (FAA) arrived in Atlantic City in 1958, there have been ongoing efforts in aviation human factors. These efforts have taken many forms and have focused on both the ground and air sides of the airspace system. Psychologists, engineers, systems analysts, computer scientists, and others have participated in the studies that have led to the numerous reports and papers cited in this bibliography. While the listing is probably not all inclusive, it covers virtually all work that is referenced in automated data bases plus publications that were identified by current and past researchers, but which never made it to the computerized listings. This bibliography is meant to highlight the work that has gone on over the years. While many of the documents cited are still available from the Technical Center library, or from the authors themselves, the editors do not suggest that everything is retrievable, and, in fact, much of the older work has been superseded by more modern technology and thinking. The research of 30 years ago has served as a foundation for the human factors engineering that that is being done today. The references are provided in alphabetical order and indexed by numbers associated with subject matter categories. Human factors research is alive and continues to progress in the FAA and at the Technical Center. Author

N95-31401# Carnegie-Mellon Univ., Pittsburgh, PA. School of Computer Science.
HUMAN-COMPUTER INTERACTION (HCI) SPECIALIZATION TRACK MASTERS OF SOFTWARE ENGINEERING (MSE) PROGRAM
CAROL L. HOOVER 1 Mar. 1995 13 p
(AD-A292895; CMU-CS-95-123) Avail: CASI HC A03/MF A01

There is an increasing demand for software to implement human-computer interfaces. Software engineers who develop these interfaces need an understanding of the interactions between the human, the available computer technology, and human tasks. They should also understand empirical methods used to evaluate the usability of existing human-computer interfaces. The Human-Computer Interaction Specialization Track, which is an option within the Masters of Software Engineering (MSE) Program at Carnegie Mellon University, enables graduate software engineering students to obtain knowledge and skills related to the design, implementation, and evaluation of interactive computing systems. Students can acquire hands-on experience in the design of computer technology to support individual users as well as group interactions. The track is flexible in that it allows students to choose their own set of track courses from a list of approved HCI courses. This report describes the track rationale and requirements and presents educational guidelines to help students select courses. The report includes a list of approved courses and brief course synopses. The report is based on the author's work in developing specialization tracks for the MSE program. The author started this work during the spring of 1993. DTIC

N95-31538# Department of the Air Force, Wright-Patterson AFB, OH. Crew Systems Directorate.
DESIGN AND INTEGRATION ISSUES OF VISUALLY-COUPLED EVALUATION Interim Report, Jul. 1991 - Oct. 1994
H. L. TASK and DEAN F. KOCIAN Mar. 1995 139 p
(Contract(s)/Grant(s): AF PROJ. 7184)
(AD-A293521; AL/CF-SR-1995-0004) Avail: CASI HC A07/MF A02

This document is the text of a short course presented at SPIE in 1992 and 1994 dealing with design and integration issues of visually-coupled systems (VCS). The VCS described are composed of a helmet-mounted display, a display image source, and a head helmet tracker. DTIC

N95-31671# Department of the Air Force, Wright-Patterson AFB, OH. Crew Systems Directorate.
VERTICAL IMPACT TESTING OF TWO HELMET-MOUNTED NIGHT VISION SYSTEMS Interim Report, Jun. 1993 - Dec. 1993
CHRIS E. PERRY Jun. 1994 25 p
(AD-A293055; AL/CF-SR-1994-0013) Avail: CASI HC A03/MF A01

The Air Force is investigating the use of helmet-mounted technology to improve pilot performance. One potential draw-back to the new helmet systems is the potential for increased neck injuries during emergency ejection due to the helmet's weight and center-of-gravity. A recent test program evaluated the risk of neck injury of two helmet-mounted night vision systems by subjecting an instrumented manikin (ADAM) to +Gz impacts using a vertical deceleration tower. The helmets were the Concept 6 from Night Vision Corporation and the ANVIS 49/49 from ITT. Results indicate that both helmets were lighter than previous helmets, and met the Interim Head and Neck Criteria. They also produced neck loads in an ACES 2 seat that are less than what a standard helmet produces in a B-52 seat, and produced neck loads in a B-52 seat that are less than the maximum (400 lbs) required for major neck injury (fracture, etc.). DTIC

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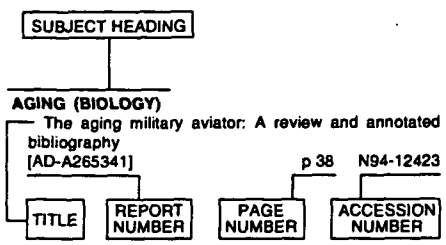

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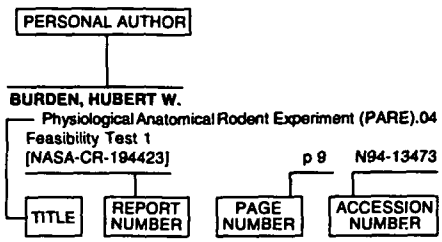

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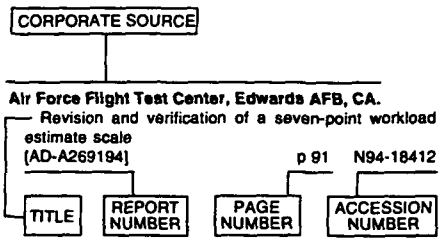

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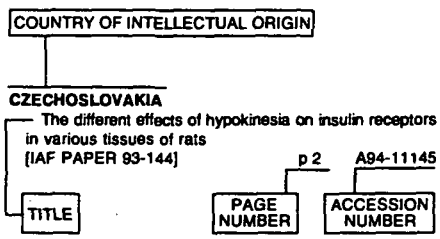

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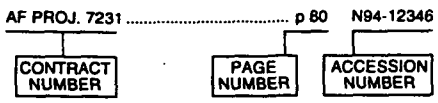

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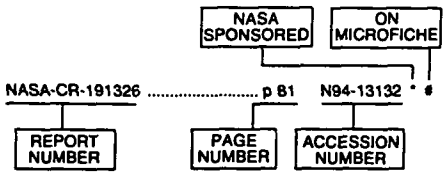

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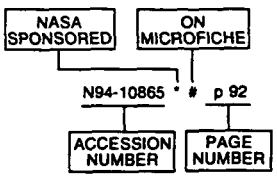

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